CONTAINER TRANSPORT: FROM SKIN BAGS TO IRON FLASKS. CHANGING TECHNOLOGIES OF QUICKSILVER PACKAGING BETWEEN ALMADÉN AND AMERICA, 1788–1848*

> The Accountant of Quicksilvers in Mexico . . . spoke truly . . . when he said that the construction of the flasks was not appropriate for public tender, because this manufacture demands more perfection than economy: economy saves [*ahorra* = 'puts aside, releases'] a little, but perfection saves [*salba* = 'redeems, rescues'] a lot.
>
> The Viceroys of New Spain and Peru (1807)[1]

In 1835 Nathan Mayer Rothschild contracted with the Spanish Crown to market the production of the great Spanish quicksilver mine at Almadén. This contract established an immensely lucrative monopoly which, with few interruptions, the Rothschilds would hold until 1921. It gave them control of a key resource for gold and silver production required by miners and refiners all over the world. Demand seemed assured for the foreseeable future, as long as precious metals retained a strategic role in finance and trade. The theme of this article is the change in the means of *packaging and transporting* this liquid metal introduced under Bourbon Spain as part of the Hispanic scientific, technological and organizational infrastructure which made possible Rothschild's quicksilver cartel.[2]

* I thank the staff of the General Archive of the Indies, Seville (AGI), the Cadiz Provincial Archive (APC), the Rothschild Archive, London, the Bolivian National Archive, Sucre (ANB), and the Potosí Historical Archive (AHP) for their kind assistance. I am grateful also to Luis Mansilla for his guidance in Almadén, to conversations with Julio Sánchez in Salamanca, Kendall Brown and Concepción Gavira in Seville, and Rafael Dobado in Madrid. Thanks, too, to the Institute of Peruvian Studies (Lima), the Arts and Humanities Research Council of Great Britain, and the School of Philosophical, Anthropological and Film Studies of the University of St Andrews for supporting the research on which this article draws; to Graeme Sandeman, cartographer at the University of St Andrews, for preparing the Map; and to Carlos Sempat Assadourian for his comments. All translations are mine.

[1] 'Los Virreyes de Nueva España y del Perú se han declarado . . .', 1807 (first lines of untitled document): Archivo General de Indias, Seville (hereafter AGI), Indiferente 1783.

[2] With American trade and quicksilver supplies interrupted by the French invasion of the peninsula (1808–14), the Regency in Cadiz was anxious to find alternative

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doi:10.1093/pastj/gtr029

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The power of quicksilver to amalgamate with silver or gold particles in powdered ore or sand was known to the ancient world from the Mediterranean and Middle East to China: when the amalgam formed, the dross was washed away and the quicksilver volatilized, leaving a piece of (fairly) pure metal. Its properties were prized and explored by Islamic and European alchemists; and the Venetians were amalgamating silver ores at the Vicenza mines in the 1540s.[3] In 1525 the German banker Anton Fugger of Augsburg contracted with the Spanish Crown to market the production of Almadén, as though in anticipation of Rothschild; and the Fuggers' profits became substantial after 1555, when industrial amalgamation began in earnest in the silver mines of Pachuca, New Spain (Mexico).

Amalgamation was introduced a few years later to the Andes using local quicksilver from another important mine discovered

(n. 2 cont.)
markets for the product of Almadén (Arabic = 'the great mine'). Reports were commissioned on its uses. One declared quicksilver among the most useful of metals in the arts and sciences. Besides its uses in silver and gold refining, its capacity to amalgamate with so many other metals, combined with its volatility, made it useful even in tiny quantities for silvering and gilding. It was amalgamated with tin to make the reflecting surfaces of mirrors. Combined with sulphur it produced artificial cinabrium, from which was derived the vermilion used in making lacquer. Dissolved in different acids, it was used in dyeing and hat-making. Physicists employed quicksilver in different demonstrations and experiments: it could be used to show the divisibility of matter and the porousness of bodies, and was used in electric machines amalgamated with bismuth. Chemists used it to collect elastic fluids, and to show the results of its union with acids, alkalis and metals. Pharmacists used it in a long series of preparations, such as mercurial pomade for curing syphilis, and, overoxygenated or sublimated, as a common corrosive. AGI, Indiferente 1783, 12 Dec. 1812. For demand in the later nineteenth century from Chinese and New York vermilion manufacturers for use in cosmetics and lacquer, see David J. St Clair, 'California Quicksilver in the Pacific Rim Economy, 1850–90', in Sally M. Miller, A. J. H. Latham and Dennis O. Flynn (eds.), *Studies in the Economic History of the Pacific Rim* (London, 1998). In this article, I concentrate on the flasks in relation to Spanish American mining demand, particularly in Potosí (Bolivia). The period considered stops with the discovery of Californian quicksilver, which in 1848 led Rothschild not to renew the contract for a few years, and challenged Almadén's dominance for a time after 1850.

[3] Sulphur and quicksilver were considered by alchemists to be the father and mother of all metals. Illuminated taps of quicksilver were created to adorn the gardens of Al-Andalus, and in the caliphate of Córdoba drops of quicksilver were used to power the movement of balances that could tell the time. Juan Vernet, *La ciencia en Al-Andalus* (Seville, 1986), 41, 63–4. For amalgamation in Vicenza, see *The Pirotechnia of Vannoccio Biringuccio: The Classic Sixteenth-Century Treatise on Metals and Metallurgy*, ed. and trans. Cyril Stanley Smith and Martha Teach Gnudi (New York, 1990).

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THE ROUTE OF THE IRON FLASKS

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in 1563 at Huancavelica, Peru.[4] The technology returned across the Atlantic to Guadalcanal in Andalusia, before being consolidated in America at the great silver-mountains of Porco and Potosí, in modern Bolivia, by Viceroy Francisco de Toledo in 1573. Here, the first period of colonial silver-refining (*c*.1538–70) had been dominated by Andean metallurgists using their own wind-furnaces to smelt high-grade ores.[5] As the grades declined, silver production began to fall, until Viceroy Toledo encouraged the formation of more than seventy refineries along the Rivera of Potosí. He created reservoirs in the mountains above the city to power hydraulic ore-crushers; legislated to regulate wage-labour at the mine-face; negotiated with Andean lords the provision of Indian corvée labourers (*mita*) to transport and tread the mineral flour, barefoot, with water, quicksilver and salt; and ordered Andean metallurgists to be taught the technology of amalgamation.[6]

But as the tailings and low-grade ores began to be amalgamated, control over industrial silver production passed to European capital. The immense volume of silver refined helped to articulate a flourishing internal market, where mining and

[4] As with most colonial American mines, Amerindian miners already knew and exploited the quicksilver of Huancavelica in pre-conquest times. The Incas had constructed an adit, from which vermilion (Quechua, *llimphi*) was extracted 'for colours and to paint themselves'. Huancavelica was later revealed by 'some Indians' to their Spanish overlord (*encomendero*), Amador de Cabrera, who declared himself the 'discoverer' and registered them in Huamanga on 1 January 1564. *Relaciones geográficas de Indias: Perú*, ed. Marcos Jiménez de la Espada, 3 vols. (Madrid, 1965), ii, 117. The Portuguese Renaissance poet and humanist Enrique Garcés successfully pioneered industrial amalgamation in the Andes with silver ores from Huamanga: see Guillermo Lohmann Villena, 'Henrique Garcés, descubridor del mercurio en el Perú: poeta y arbitrista', *Anuario de Estudios Americanos*, v (Seville, 1948). Recent analyses of gold objects from Sican on the Peruvian coast have shown quicksilver traces, leading to claims that small-scale amalgamation was also practised in the Andes before the Spanish conquest: William E. Brooks, Gabriela Schwörbel and Luis Enrique Castillo, 'Mercury and Small-Scale Gold-Mining in Ancient Peru', paper delivered at the 28th North-East Conference on Andean Archaeology and Ethnohistory, State University of New York at New Paltz, 3–4 Oct. 2009.

[5] Native Andeans revealed Porco to the Spanish in 1538, followed by Potosí in 1545: see Tristan Platt and Pablo Quisbert, 'Tras las huellas del silencio: Potosí, los Inkas y el Virrey Toledo', in Pablo José Cruz and Jean-Joinville Vacher (eds.), *Mina y metalurgia en los Andes del Sur, desde la época prehispánica hasta el siglo XVII* (Sucre, 2008).

[6] Peter Bakewell, *Miners of the Red Mountain: Indian Labor in Potosí, 1545–1650* (Albuquerque, 1984); Tristan Platt, Thérèse Bouysse-Cassagne and Olivia Harris, *Qaraqara-Charka: Mallku, Inka y Rey en la provincia de Charcas (siglos XV–XVII). Historia antropológica de una confederación aymara* (La Paz, 2006).

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urban demand for supplies and materials established separate regional spheres of production: Potosí attracted merchandise from many different regions throughout the Andes and the world. At the same time, silver that was not required as payment for supplying the cities and reinvesting in the mines — the royal fifth (*quintos*), and private bars and coin exchanged for European wares introduced by the Andalusian merchant guilds — flowed down to Lima en route to Panama, Portobelo and Spain.[7] Increased by smuggling, American silver then circulated throughout Europe, and much percolated across the Middle East, or was exported via the Cape of Africa, to India, the Far East and China.[8]

Quicksilver was also available from a few other sources. In the late eighteenth century, additional supplies for Spanish America had come from Idria in Austro-Hungary.[9] Between 1786 and

[7] Carlos Sempat Assadourian, 'Base técnica y relaciones de producción en la minería de Potosí', in José Luis Peset (ed.), *Ciencia, vida y espacio en Iberoamérica*, 3 vols. (Madrid, 1989), ii; Carlos Sempat Assadourian, *El sistema de la economía colonial: mercado interno, regiones y espacio económico* (Lima, 1982).

[8] For comparative studies of Mexican and Peruvian silver production, see D. A. Brading and Harry E. Cross, 'Colonial Silver Mining: Mexico and Peru', *Hispanic Amer. Hist. Rev.*, lii (1972); Richard L. Garner, 'Long-Term Silver Mining Trends in Spanish America: A Comparative Analysis of Peru and Mexico', *Amer. Hist. Rev.*, xciii (1988). For Potosí's regional silver production in the early colonial period, see Peter J. Bakewell, 'Registered Silver Production in the Potosí District, 1550–1735', *Jahrbuch für Geschichte von Staat, Wirtschaft und Gesellschaft Lateinamerikas*, xii (1975). For the eighteenth-century nadir and recovery, see Enrique Tandeter, *Coercion and Market: Silver Mining in Colonial Potosí, 1692–1826* (Albuquerque, 1993). For precious metal flows to India and the Far East, via Europe or via Acapulco and Manila, see M. N. Pearson, 'Asia and World Precious Metal Flows in the Early Modern Period', in John McGuire, Patrick Bertola and Peter Reeves (eds.), *Evolution of the World Economy, Precious Metals and India* (New Delhi and Oxford, 2001). For American silver in the Middle East, see Şevket Pamuk, *A Monetary History of the Ottoman Empire* (Cambridge, 2000). Pierre Chaunu estimated the amount reaching China at a third of the total production of the American mines; and China, where silver was valued particularly highly, had moved to the silver standard in 1570, on the eve of Potosí's quicksilver revolution. See Richard von Glahn, *Fountain of Fortune: Money and Monetary Policy in China, 1000–1700* (Berkeley, 1996). At the same time, China was also absorbing most of Japan's silver production: see Pearson, 'Asia and World Precious Metal Flows'.

[9] The mines of Idria lie in present-day Slovenia. In the mid eighteenth century, according to a report from 1812, Holland bought most of Idria's quicksilver until the Spanish government celebrated, in 1784, a six-year contract with the emperor of Austria for 6,000 quintals per annum. From 1757, a Dutch company had had a contract with Austria for 3,000 quintals per annum. Holland possessed the trade secret of how to manufacture vermilion, with which it supplied Europe, apart from a small quantity of 'Chinese vermilion' introduced from China by England and Spain, known as *Tchutcha* (Chinese, *zhu-sha*): very beautiful and pure, but expensive.

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1799 Idria provided 36 per cent of the quicksilver imported to New Spain.[10] Mexico also received bamboo canes full of quicksilver from the Chinese mines in the provinces of Kweichow and Yunan, which came across the Pacific via Canton, Manila and Acapulco.[11] As far as Peru and Potosí were concerned, Huancavelica made imports unnecessary before the mid eighteenth century, apart from a brief period between 1620 and 1650 when Potosí's declining boom still attracted additional quicksilver from Almadén and Idria; but, as production fell further, Huancavelica quicksilver covered Andean needs and a little was even exported to New Spain.

From a low point in 1735, however, Potosí mining demand slowly recovered. Since the Huancavelica quicksilver mines were now in decline, from the 1750s Potosí miners looked to a renewed expansion of production at Almadén (together with that of the nearby deposit of Almadenejos).[12] Only war interrupted the growth in exports from Almadén, in 1802–3 and again in 1808–12 (see Figure). In the nineteenth century Huancavelica's recovery was limited to producing around half the quicksilver required by the miners of the new Republic of Peru, who had to buy most of the other half from Almadén.[13] Indeed, the silver

(n. 9 cont.)
The rest of the production of Idria was consumed in Germany, Hungary and Italy, and a little in Turkey. AGI, Indiferente 1783, 12 Dec. 1812.

[10] Rafael Dobado Gonzáles, 'Las minas de Almadén, el monopolio del azogue y la producción de plata en Nueva España en el siglo XVIII', in Julio Sánchez Gómez, Guillermo Mira Delli-Zotti and Rafael Dobado, *La savia del imperio: tres estudios de economía colonial* (Salamanca, 1997).

[11] AGI, Indiferente 1791. Manila, 9 Nov. 1810. In 1807, Chinese annual consumption was estimated at 10,000 picos (1 pico, or pecul = 1 quintal and 37½ pounds), of which 4,000–5,000 were sold in Fuchan (4 leagues from the capital).

[12] For the late eighteenth- and early nineteenth-century recovery of Potosí silver production, see Tandeter, *Coercion and Market*. For the recovery of Almadén, see Dobado, 'Las minas de Almadén'. For the early years of Huancavelica, see Guillermo Lohmann Villena, *Las minas de Huancavelica en los siglos XVI y XVII* (Seville, 1949). For Huancavelica's capacity in the later seventeenth century to supply a little quicksilver to New Spain as well as to Peru, see M. F. Lang, 'New Spain's Mining Depression and the Supply of Quicksilver from Peru, 1600–1700', *Hispanic Amer. Hist. Rev.*, xlviii (1968). For the late eighteenth-century collapse, see M. F. Lang, 'El derrumbe de Huancavelica en 1786', *Histórica* (Lima), x (1986). For health conditions at Huancavelica, see Kendall W. Brown, 'Workers' Health and Colonial Mercury Mining at Huancavelica, Peru', *Americas*, lvii (2001).

[13] New capital investments during the 1830s and 1840s led to a production of 3,000 quintals at Huancavelica in 1847: José Deustua, *La minería peruana y la iniciación de la República, 1820–1840* (Lima, 1986). In 1856 a Spanish source puts Huancavelica's output at slightly less than 2,000 quintals: Luis María Sánchez Molero y Lletget,
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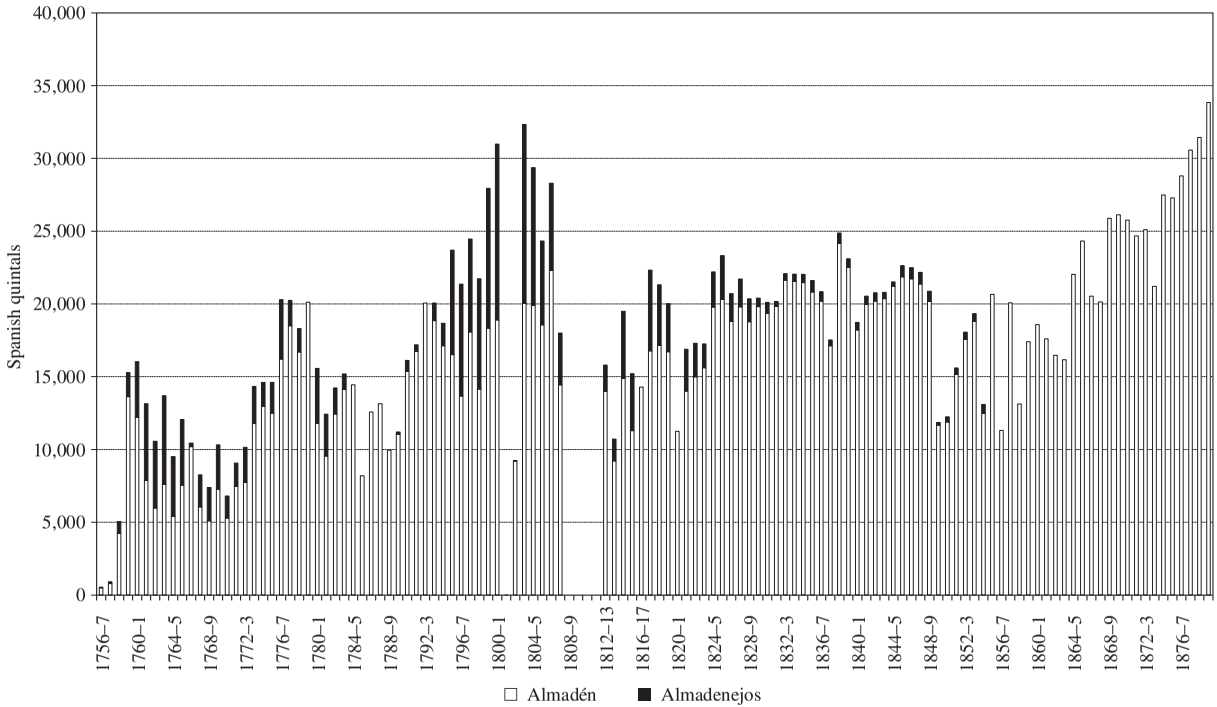
PRODUCTION OF ALMADÉN AND ALMADENEJOS, 1756–1880*



* Sources: for 1756/7–1854/5: 'Rafael Dobado, 'El trabajo en las minas de Almadén, 1750–1855', 3 vols. (Complutense Univ. of Madrid Ph.D. thesis, 1989), iii (table A3), 'Producción anual de azogue de las minas de Almadén y Almadenejos'; for 1757–1821: appendix (table A2), p. 480, in Dobado's published work (cited in n. 10 above); for 1855–80 (Almadén only): Victoriano Martín Martín, *Los Rothschild y las minas de Almadén: el servicio de la deuda pública español y la comercialización del mercurio de Almadén* (Madrid, 1980), 493–4.

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production of Mexico, Chile and Bolivia during the early Republican period was almost wholly dependent on Almadén, before the production of New Almaden in California came on line after 1848.[14]

By the late eighteenth century, demand for quicksilver had expanded to include the silver miners of Germany and central Europe, previously wedded to the smelting furnace for refining their ores. Following the Metallurgical Congress held in 1786 at Banská Štiavnica (Slovakia), the German miners decided to follow Spain's lead in the art of amalgamation, although they looked to the mines of Idria for their quicksilver supplies. The Andalusian metallurgist Álvaro Alonso Barba (1569–1662), a parish priest as well as a miner and refiner in colonial Charcas (Upper Peru), was revindicated notwithstanding the alchemical theory of matter with which he worked. By reading in Spanish the Third Book of Alonso Barba's *Art of Metals* (1640), the Transylvanian mineralogist Count Ignaz von Born, director of the Natural History Museum in Vienna, was able in the 1780s to repeat Barba's experiments, and show that the amalgamation of silver ores by boiling with salt and quicksilver in copper cauldrons (later upgraded as the Freiberg 'cold method' of rotating wooden barrels) was possible, swift and profitable. These 'new'

(n. 13 cont.)
'Memoria sobre azogues', *Revista Minera*, new ser., vii (1856), 629. A little additional Peruvian quicksilver also came from the mine at Chonta: see, for example, Fredrik Huth & Gruning to N. M. Rothschild, Lima, 23 Nov. 1844, 'Although the Chonta and Huancavelica mines will go a long way to supply the wants in the Cerro [de Pasco], still the supplies from Europe [i.e. Almadén] will have to supply the silvermines in the north': Rothschild Archive, London (hereafter RAL), XI/38/149A, Huth & Gruning Correspondence. Some Chinese quicksilver also found its way to the Cerro de Pasco silver mine in the early Republican period: see Fredrik Huth & Gruning to N. M. Rothschild, Lima, 9 Oct. 1844, 'There is still a small lot [of] China quicksilver in the market in bamboo bottles, held at 130$ with six month credits; the quality of the last sold here was found good, but the package in bamboo bottles is a great objection, as they are liable to get injured on the roads in the interior, although packed in cases. Of 60 bamboo bottles sent up in cases some months ago to the Cerro de Pasco from this, two ran out entirely and others arrived more or less short of contents. If packed in iron flasks the quicksilver would probably sell at the same price as the Spanish, if not adulterated, as has happened in former years': RAL, XI/38/149A, Huth & Gruning Correspondence.

[14] Chile also exploited a little quicksilver in the mines of Punitaqui: see Jorge Pinto Rodríguez, *Las minas de azogue de Punitaqui* (Coquimbo, 1981). The Mexican quicksilver mine at Gigante, Guadalcazar, met a small part of Mexico's needs in the nineteenth century: see a mention in Alma Parra, 'Mercury's Agent: Lionel Davidson and the Rothschilds in Mexico', *Rothschild Archive Rev.* (Apr. 2007 – Mar. 2008).

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technologies were then re-exported to Mexico and South America, where they were seen as 'modern' methods of amalgamation in nineteenth-century refineries.[15]

During the late imperial period, the Spanish Bourbons were anxious to keep American miners supplied with cheap quicksilver. But with the Napoleonic invasion of Spain (1808–14), the French tried to take control of Almadén's production; and when the last Spanish shipments at subsidized prices ended in the early 1820s, French speculation pushed prices on the Pacific coast of America to new heights. In 1826 the British consul in Bolivia, Joseph Pentland, lamented the lack of British participation in this, the richest branch of South Pacific commerce, which was entirely in the hands of the French.[16] A first five-year contract with the Crown for the sale of quicksilver from Almadén was signed in 1830 by the Bordeaux merchant Iñigo Ezpeleta, a business partner of the Rothschilds. He decided to place his quicksilver in the London and Paris markets through Nathan Mayer and James de Rothschild, with London being the principal outlet.[17] In 1833, he sent 16,000 quintals from Cadiz to Britain, more than twice the amount sent in 1832. In 1834, Ezpeleta helped Nathan Mayer send consignments to the Valparaiso branch of Huth, Gruning's commissions house, who would become Rothschild's main agent in the South Pacific.[18] Gentlemanly gifts of French wines and American tobaccos accompanied the deal. The commercial structure was being created that would be sealed in 1835, when Rothschild took over the contract and 20,668 quintals were imported to Britain, almost all that year's production at Almadén (see Table 1).

In the nineteenth century, therefore, a branch of production and distribution broadly derived from the period of Spanish domination was revived and expanded, with significant modifications,

[15] For the recovery of Alonso Barba's cauldrons in nineteenth-century Bolivia, see Tristan Platt, 'The Alchemy of Modernity: Alonso Barba's Copper Cauldrons and the Independence of Bolivian Metallurgy (1790–1890)', *Jl Latin Amer. Studies*, xxxii (2000).

[16] Joseph B. Pentland, *Informe sobre Bolivia, 1826* (Potosí, 1975); original English MS of 1826 was translated into Spanish by Jack Aitken Soux.

[17] Iñigo Ezpeleta to N. M. Rothschild, Bordeaux, 9 Jan. 1834: RAL, XI/38/94, Ezpeleta, I. & Co., and Ezpeleta, F. X. & Co. Correspondence, 1834–48.

[18] Iñigo Ezpeleta to N. M. Rothschild, Bordeaux, 28 Apr. 1834. Frederik Huth and Frederik Gruning were German immigrants to Britain, where they arrived in 1808 from Hamburg and Bremen respectively. They had interests in Spain and Spanish America, which they supplied from their bases in London and Liverpool.

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for several decades under the Spanish American republics. In spite of the collapse of the Spanish imperial monetary union, Spanish America continued to export considerable amounts of silver to Europe, now in exchange for British and French manufactures.[19] In 1835, the Rothschilds had already gained control of the mines of Idria; with Almadén they consolidated their hold on a global commodity, which was essential for the production of silver, and whose production and supply was a precondition for the circulation of other commodities. Chinese demand for American silver continued strong after Independence; we have references to it in the 1840s, in the Andes as well as in Mexico.[20] But, increasingly, the growth of free-trading policies led the Andean internal market to be by-passed, with disastrous results in the case of countries like Bolivia, which had inherited the Potosí mines. From 1873, unminted silver bars and, eventually, unrefined ore were exported legally from Bolivia (previously much uncoined silver had also been smuggled out), and this put an end to the role of silver coins as means of exchange in Bolivian internal markets.

While central Europe was learning and adapting Hispano-Islamic methods of amalgamation, another less known transformation was taking place in the *packaging* of quicksilver. This Spanish invention was another essential precondition for Ezpeleta's and Rothschild's monopolies. The liquid metal was

[19] For British trade with Latin America, see Rory Miller, *Britain and Latin America in the Nineteenth and Twentieth Centuries* (London and New York, 1993). Miller points out that before 1859 silver is omitted from British import statistics, but was nevertheless flowing in to pay for British exports. He suggests pre-1859 silver imports might be quantified if transported in British Admiralty warships, but the Huth & Gruning Correspondence in the RAL shows that, in the case of quicksilver, silver and other forms of payment were also carried in merchant vessels.

[20] Chinese trans-Pacific demand for Peruvian 'hard dollars' (*pesos fuertes*) can be seen in correspondence from the Lima branch of Fredrik Huth & Gruning's commissions house to N. M. Rothschild, for example Lima, 26 Jan. 1844: 'Hard dollars and silver bars have been very scarce during the last three months owing to the increased demand from England in consequence of the falling-off of the produce remittances and the large shipments last year to China'. Also Lima, 4 Jan. 1845: 'Hard Dollars would be worth 8¾ per cent premium on board; the Mint is, however, not coining at present and the few [hard dollars] which existed have all been bought up and for the greater part shipped to China; as soon as the government is properly settled and a new president elected the Mint will probably resume the coining of silver': RAL, XI/38/149A, Huth & Gruning Correspondence. For Chinese demand for American silver coinage before and after American Independence, see Alejandra Irigoin, 'The End of a Silver Era: The Consequences of the Breakdown of the Spanish Peso Standard in China and the United States, 1780s–1850s', *Jl World Hist.*, xx (2009).

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TABLE 1

QUICKSILVER PRODUCED AT ALMADÉN AND IMPORTED TO THE UK, 1816–1839*

Year	Almadén quicksilver			Total UK imports (£)
	Quantity produced (cwt)[a]	Imported to UK (to nearest cwt)	Value of UK imports (£)[b]	
1816	14,285	3,321	66,413	26,374,929
1823	15,625	4	79	34,591,264
1832	21,631	7,816	156,326	43,237,417
1833	21,537	15,977	319,547	44,529,287
1834	21,469	7,734	154,673	47,908,931
1835	20,820	20,668	413,358	47,463,601
1836	20,206	19,511	390,217	55,733,419
1837	17,134	19,781	395,624	53,224,874
1838	24,173	14,504	290,076	59,878,905
1839	22,528	22,737	454,739	60,346,066

* Source: *Circular to Bankers*, no. 712, 17 Dec. 1841.

[a] Here 1 cwt = approximately 1 Spanish quintal = 100 Spanish lbs.
[b] Values calculated at 4s. per lb.

previously transported in boxes of skins, but leakages and losses had occupied too much of the royal accountants' time; so in 1788 an employee of the Spanish Crown, Josef Antonio Pizarro, proposed decanting it into iron flasks (*frascos*, or *vasijas*; *potiches* in the French quicksilver trade).[21] After many teething problems, the idea was finally adopted, and by the time of South American Independence the use of iron flasks, each containing 75 Spanish pounds of quicksilver, had become standard. Their presence symbolizes the adaptation of amalgamation to the nineteenth century's new age of industry.

Although it may seem unremarkable to us today, the idea of the iron flasks was greeted with caution by the Spanish Crown. Scientific advisers were called to give their often ill-informed opinions. Some feared that quicksilver might amalgamate with iron, while others invoked metallurgical developments in central

[21] Josef Pizarro, a native of Trujillo (Extremadura), was a 'legitimate descendant of captain Hernando Pizarro, marquis of the Charcas and Autillo, and of his wife Francisca Pizarro Atahualpa, daughter of the Adelantado Francisco Pizarro (brother of Hernando) and of the Infanta sister of the Emperor Atahualpa': AGI, Indiferente 1785. Seville, 19 Oct. 1796; also Josef Pizarro to Ex Sr D Francisco de Saavedra, Seville, 23 Jan. 1799: *ibid.*

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Europe to refute this, while a few pointed out that iron had been used as a reagent in Potosí silver-refining since the sixteenth century, and that there was no American evidence to support such fears.[22] Yet scientists continued to be doubtful, because they still had no satisfactory 'new chemical' theory of amalgamation. As with silver-refining, we find new technologies rooting themselves in the state of the metallurgical art, and then setting challenges to the 'new chemistry'. Alchemical practice provided a laboratory of experimentation in which metallurgists continued to invoke early modern paradigms, because these expressed and rationalized (however esoterically) the practical knowledge of refining.

Why did the iron flasks take so long to become accepted?[23] The delay reveals not so much intractable technical problems as a constellation of social, political and cultural factors that included the tensions between private and government sectors within the economy of late Bourbon Spain. A major disruption, as we shall see, was the Peninsular War against French invasion, which in 1808 interrupted contracts and cut trade routes. Moreover, far from making possible any great savings, modernization in this instance involved introducing a more expensive, if more efficient and expandable, technology of container transport from which the Rothschilds were able to profit. I argue that, for the accountants of late Bourbon Spain, efficiency was no less important than costs, and this leads me to raise the more general question of the *role of accountants* in processes of modernization.

The old method of transporting this heavy, liquid metal in boxes of leather skins was becoming unacceptable. Skins deteriorated at sea, and it was impossible to eliminate leakages over thousands of leagues with repeated trans-shipments, reloadings, reweighings and repackagings. Could iron flasks defeat quicksilver's uncanny powers of escape? Even to build *one* flask of a determinate weight, capacity and security required considerable

[22] For the introduction of iron as a reagent to Potosí in the 1590s, see Enriqueta Vila Vilar, 'Ensayos metalúrgicos en Potosí: Carlos Corzo de Leca y su nuevo método de amalgamación', in Maria Justina Sarabia Viejo (ed.), *Europa e Iberoamérica: cinco siglos de intercambios*, 3 vols. (Seville, 1992), ii.

[23] The delay was already pointed out in 1807: 'It is astonishing that nineteen years have passed [i.e. since 1788] without this interesting project having been fully realized: at last, since the beginning of this year the contract for 33,000 flasks has begun to run, which will carry 24,750 quintals, and which should produce the great advantages we have awaited too long in vain'. See 'Los Virreyes de Nueva España y del Perú se han declarado . . .': AGI, Indiferente 1783.

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skill: sheet iron had to be cast, hammered, cut, moulded, joined and welded; and some device had to ensure the mouth was safely stopped. The use of wrought iron was considered; and was the fierce heat of fossil fuel preferable, or the steadier heat of charcoal? For skills in ironworking, the place to look to within Spain was the northern iron deposits and industry of the Basque country and Cantabria.

The idea of building sixty thousand iron flasks to solve the packaging problem was the brainwave of Josef Pizarro. He had served the Crown in the garrison of Cadiz from 1757 to 1783, and then spent a year as commander-general of the garrison of Caracas in the Captaincy of Venezuela.[24] In 1784 he returned home with malaria, and in 1788 was in Madrid seeking appointment as the Commissary of Quicksilver Packaging in Seville. The project of the flasks was designed to strengthen Pizarro's petition: a service from the subject would, he hoped, be reciprocated with a favour from the Crown.[25]

Encouragement came from Antonio Valdés, finance minister for Spain and the Indies, as Josef's brother Miguel later recalled. It was Valdés who suggested the capacity of 75 lbs (¾ of a Spanish quintal of 100 lbs) which would later become standard in the trade.[26] By 1800, both forms of container were in use, and by 1804 the flasks, still of variable weight but now with an approximate capacity of 75 lbs of quicksilver, were being shipped to the Americas alongside boxes of skins with a capacity of 150 lbs (see Table 2).[27] However, it was not until 1816 that a key contract, left in suspense following the French invasion of 1808, was reactivated; and only thereafter did iron flasks finally replace boxes of skins in international trade — almost thirty years after first being mooted.

[24] 'Antecedentes de José Pizarro en la Secretaría de Indias (1785–86)': AGI, Indiferente 1784-A.

[25] 'Construcción de vasijas de hierro para la conducción de azogues', extract 4, 'Pizarro promised utilities of 515,000 pesos per annum, basing his argument on the fact that, in 1786, 423 quintals of quicksilver were lost of the 3,500 quintals carried by the frigate "Dolores" of the Philippines Company . . . calculating more than 500 in each annual cargo of 16,000, which at 1,000 pesos per quintal amounted to 500,000 in losses as well as 16,000 invested in packaging': AGI, Indiferente 1785. See also Table 3.

[26] Miguel Pizarro to the Ex Sr don Juan de Erro, Azpeitia, 20 Oct. 1823: AGI, Indiferente 1785.

[27] See also Josef Pizarro to Rafael Orozco, Trocadero, 4 Nov. 1806: AGI, Arribadas 293.

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Nathan Mayer Rothschild's agent in Andalusia, Domingo Anzoateguí, was an established Cadiz merchant who was involved in the quicksilver trade during the 1820s, and had already been agent for Iñigo Ezpeleta (he was Ezpeleta's brother-in-law).[28] Anzoateguí was responsible for receiving flasks of quicksilver from Crown officials in Seville or Cadiz, storing and shipping them to Bordeaux and London, or directly to America. For his part, Rothschild contracted in 1835 to sell the production of an established industry, still managed by the Crown with its own personnel and infrastructure, although, rather than follow the old Crown policy of subsidizing prices, he preferred the French policy of pushing prices up as far as they would go. Still, Rothschild's cartel was rooted in a form of economic and spatial organization which retained characteristics of its history as a dependency of the Spanish Crown. As part of this inheritance, the Bourbon invention of container transport with iron flasks became a crucial element in the post-Napoleonic configuration of global finance and commerce.[29]

I

In order to understand the conditions of emergence of new industrial technologies, we must look at aspects of economic and social life that stand out amidst the everyday flow, appearing to some contemporaries, often in the face of long usage, as unsatisfactory and in need of change. Why did innovation take place *then*? With quicksilver packaging, the motor was probably the accountants' awareness of the Bourbon state's fiscal problems, and its desire to eliminate waste and increase income from the colonies with the help of new science and technology.

Quicksilver packaging had long been a source of concern to Bourbon officials. Beads of metal tended to wriggle their way out of the skin bags; so each bag was placed inside a pot and

[28] The Basque origins of both their names suggest that Ezpeleta and Anzoateguí may have entered the trade in Bordeaux and Cadiz together with the iron flasks.

[29] For the economic situation in Spain which led to the government subscribing the contract, see Victoriano Martín Martín, *Los Rothschild y las minas de Almadén: el servicio de la deuda pública español y la comercialización del mercurio de Almadén* (Madrid, 1980). For the European and global financial politics surrounding the deal, see Niall Ferguson, *The House of Rothschild*, i, *Money's Prophets, 1798–1848* (Harmondsworth, 1998).

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TABLE 2

SHIPMENTS OF QUICKSILVER FROM CAÑO DEL TROCADERO, 1804*

Date	Destination	Ship	Iron flasks[a]	Wooden boxes[b]	Quintals
8 Jan.	Veracruz	Crown frigate *Anfitrite*		1,334	2,001
14 Jan.	Veracruz	Crown frigate *Venganza*		667	1,000.50
14 Jan.	Veracruz	Crown frigate *Venganza*	933		699.75
14 Jan.	Veracruz	Crown frigate *Rufina*		1,134	1,701
31 Jan.	Lima	Private frigate *La Primavera*		1,334	2,001
11 Feb.	Montevideo	Private frigate *Hermosa Andrea*		667	1,000.50
12 Feb.	Veracruz	Private frigate *Buen Ayre*		1,000	1,500
13 Feb.	Veracruz	Private frigate *Medea*		1,667	2,500.50
25 Feb.	Veracruz	Private frigate *Santa Ana* (alias *Dido*)		734	1,101
7 May	Montevideo	Private corvette *Buen Concepto*		503	754.50
7 May	Montevideo	Private corvette *Buen Concepto*	1,201		900.75
19 July	Veracruz	Private frigate *Nuestra Señora del Pilar* (alias *La Fortuna*)	1,334		1,000.50
13 Aug.	Guatemala	Private frigate *Balbanera* (alias *Esmeralda*)	2,000		1,500
12 Sept.	Lima	Private frigate *San Fernando* (alias *Príncipe de Asturias*) of the Royal Philippines Company	4,000		3,000
18 Sept.	Ferrol	Crown brigantine *Volador*	855		641.25
1 Oct.	Veracruz	Crown frigate *Pomona*		800	1,200
2 Oct.	Veracruz	Crown frigate *Pomona*		20	30
13 Oct.	Veracruz	Crown frigate *Matilde*		1,134	1,701
3 Nov.	Veracruz	Frigate *Marinera*		1,000	1,500
TOTAL			10,323	11,994	25,733.25

* Source: AGI, Arribadas 293. 'Estado expresivo de las partidas de azogue de las Reales Minas de Almadén que ha remitido SM (QDG) a sus dominios de Yndias el año po pasado con distinción de los destinos a que se han dirijido, Buques conductores, frascos de fierro, cajones y dia en que se han cargado', Caño del Trocadero, Almacenes de SM, 20 Feb. 1805. Juan Pizarro.

[a] The flasks were of 75 Spanish lbs, or 3 *arrobas* of 25 lbs each (4 *arrobas* = 100 Spanish lbs = 1 Spanish quintal).

[b] The boxes were of 1½ quintals each.

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each pot in a cask placed with others inside a box.[30] Estimated losses were still alarming, and were meticulously translated by royal accountants into quantities of silver that could no longer be refined.[31] We shall follow the skins from Almadén until their stowage in the holds of ocean-going ships, to illustrate the problems the flasks were designed to solve.

Ore at Almadén was carted from the winch to the furnaces, where it was broken into walnut-sized pieces and fired. In the Bustamante method, introduced in 1646 from Huancavelica (Peru), the quicksilver vapour passed along inclined dried mud tubes (*aludeles*) extending from the furnace. Inside each tube the liquid quicksilver condensed from the fumes and flowed through an orifice into a recipient, or sink (*pila*), from which it was poured off into skin bags.[32] These were stored in the establishment's packaging office, before being sealed in boxes of 1½ quintals.

Skins cost 32–33 *reales* per dozen in Madrid, and were sent to Almadén by the Crown Inspector of Skins.[33] A lack of skins would leave the sinks full, and the *aludeles* blocked for the next firing.

[30] Rafael Orozco to Cristóbal de Góngora, Cadiz, 7 Jan. 1813: AGI, Arribadas 293. Orozco cited the Director of Packaging, Juan Pizarro (Josef's son), who had written that 'each of the pots (*macetas*) must be checked one by one, because the boxes are in a bad state; the skins must be examined to see if they are good, replacing those that are considered defective, replacing the pots in the casks (*barriles*), and these in the boxes, securing them again, and then they can be transported to New Spain'; and 4,500 *reales* were given to the warehouse guard, 'because payment must be made to the lads who manage the boxes, the carpenter, a skilled assistant to help the Master Packer, [and] the necessary skins must be bought and some new boxes, since several are broken, as well as ropes, cords and nails (*trincas, trallas y clavazón*): this is as far as the 1,020 boxes at present in my warehouse are concerned'.

[31] Using one of the problematic ratios (*correspondidos*) between consumption of quicksilver and production of silver. For another case of quicksilver loss from skins in transit, reaching over 800 quintals in a consignment of just 2,500, see 'Los Virreyes de Nueva España y del Perú se han declarado . . .': AGI, Indiferente 1783.

[32] For a technical description of the Bustamante furnaces (which underwent improvements in Spain), see Luis Mansilla Plaza, 'La metalurgia del mercurio en Almadén durante la época colonial', in Julio Sánchez Gómez and Guillermo Mira Delli-Zotti (eds.), *Hombres, técnica, plata: minería y sociedad en Europa y América, siglos XVI–XIX* (Seville, 2000). In 1806 Leopold furnaces were introduced from Idria. With these, refining took six days instead of three with Bustamante furnaces, which were therefore favoured by refining experts. But Leopold furnaces were preferred by mid nineteenth-century administrators, perhaps (it has been suggested) to reduce their dependence on the refiners' empirical knowledge. See Rafael Dobado, 'El trabajo en las minas de Almadén, 1750–1855', 3 vols. (Complutense Univ. of Madrid Ph.D. thesis, 1989).

[33] In 1812, during the French occupation of Madrid, skins were more difficult to find; and it was debated whether to bring them from England through the house of Wetherell & Co., which had an agent in Cadiz. Juan Bautista de Erro to Ciriaco

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To pack 24,000 quintals of quicksilver, a good year's production at Almadén, 12,000–13,000 dozen (144,000–156,000 skins) were necessary, averaging between six and seven skins per quintal (or nine to eleven skins per box of 150 lbs). This number cost around 400,000 *reales*, excluding carriage costs from Madrid to Almadén and Seville. The money was unrecoverable since the skins were worthless on reaching America, and royal officials over the Atlantic often requested fresh skins for repacking the quicksilver after its ocean voyage.[34]

Skins came in different sizes, holding from a few pounds to more than an *arroba* (25 Spanish lbs). Boxes of full skins were sealed with boards and nails, and bound with cords, before being transported through the Sierra Morena to Seville, where they were unloaded in the Reales Atarazanas (Crown warehouses) close to the river Guadalquivir.[35] In the dry months the journey took three to four weeks following the circuitous but broad trail suitable for slow-moving oxen pulling heavily laden carts. Each could carry fifteen to twenty boxes (30–45 quintals), and sometimes three hundred to four hundred carts travelled together bearing from 9,000 to 12,000 quintals.[36] When the roads were impassable, as often between October and March, boxes were sent in a week with horses or mules. These moved faster along a narrow, direct road through the mountains, but each animal carried only two boxes.[37]

(n. 33 cont.)
Gonzalez Carbajal, of the Overseas Government Department, Almadén, 28 Oct. 1812: AGI, Indiferente 1791.

[34] In 1807, the transport of 20,000 quintals from Veracruz to Mexico was estimated at 15,622 *reales* (well over 1,000 American pesos) in new skins alone. 'Los Virreyes de Nueva España y del Perú se han declarado . . .': AGI, Indiferente 1783.

[35] Atarazana, from the Arabic for 'workshop', thence arsenal or warehouse; the building can still be visited in Seville. Quicksilver was sometimes floated down from Córdoba to Seville; but the river was crossed by frequent weirs, making repeated trans-shipments necessary. The plan to make the Guadalquivir navigable below Córdoba was revived in 1837 by the Cadiz Ayuntamiento and Board of Trade. See *Economist, Joint-Stock Bankers' Jl and General Commercial Chron.*, 12 Aug. 1837, 101.

[36] But loads varied: in March 1839, 357 carts left Almadén for Seville carrying only 4,380 quintals. D. P. Anzoateguí to N. M. Rothschild, Seville, 16 Mar. 1839: RAL, XI/38/3–5, Anzoateguí Correspondence.

[37] According to the governor of Almadén in 1836, the cart roads became passable again in April. Manuel de la Puente to D. P. Anzoateguí, Almadén, 1 Feb. 1836: RAL, XI/38/3–5, Anzoateguí Correspondence. But on 6 December 1838, seventy-six carts were still setting out from Almadén carrying 1,140 flasks; they were expected to arrive by 6 January. A few days later 114 horses left bearing 228 flasks which had already arrived by 25 December. Another 2,782 flasks were to be sent by packhorse as soon as

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Boxes had to be got out of the warehouse and put on the road to Seville if space was to be freed for storing and boxing new skins. Otherwise another bottleneck would block the smooth flow of quicksilver.[38] As important as the supply of sinks and skins, therefore, was the supply of carts and carters. To attract them, the Crown forbade private enclosures of the common pastures (*dehesas*) that lined the Royal Road between Almadén and Seville, and each November the office in Almadén had to order sufficient skins from Madrid in time to have quicksilver packaged and waiting for the carters in the spring. Otherwise the animals would eat all the pastures, and if the carts returned empty, compensation had to be paid, or they would not return the following year.[39] So, after the winter, carts contracted in Seville jostled together in Almadén, bringing supplies to be replaced with quicksilver on the return trip. Transport continued to be abundant until the end of May. Then the Andalusian summer became too much for animals from cooler climates, although in the 1830s, and probably before, supplies to Seville followed a trimestral schedule, using animals from Constantina, Cazalla and La Parra.[40]

(n. 37 cont.)
animals became available. D. P. Anzoateguí to N. M. Rothschild, Seville, 25 Dec. 1838: RAL, XI/38/3–5, Anzoateguí Correspondence.

[38] In 1800 and 1801, 'the scarcity of skins, their bad quality, and the lack of warehouse space, led officials to store much of the 47,000 quintals which could not be sent packaged to Seville in the Prison for Forced Labourers', doc., n.d.: AGI, Indiferente 1783.

[39] 'Perjuicios que se siguen de no estar en Almaden los baldreses en tiempo oportuno' [Problems which Follow from Skins not Being in Almadén at the Right Time], n.d.: AGI, Indiferente 1783. Requisitioning 2,000 carts, though legal, was expensive, unpopular, and impractical except in emergencies such as the French invasion. In December 1812, there was panic in Cadiz lest the French should lay hands on 'this precious mover of our industry and wealth'. Carters were requisitioned, but failed to turn up, so two commissioners with soldiers were placed at busy points on the road 'and embargoed all drovers without cargo going to Andalusia'. Another device was to exempt carters from military service, a popular solution, although the 'carting business is reduced to scarcely a tenth of what it was before . . . the [French] War'. Juan Bautista de Erro to Ciriaco González Carbajal, Governación de Ultramar, Almadén, 29 Dec. 1812: AGI, Indiferente 1791.

[40] See RAL, XI/38/3–5, Anzoateguí Correspondence, *passim*, for example D. P. Anzoateguí to D. Weisweiller, Cadiz, 10 Feb. 1836. Anzoateguí explained that the trimestral delivery dates should be July, October, January and April (i.e. 5,000 quintals each trimester assuming an annual production of around 20,000 quintals in Almadén). He asked Weisweiller, Rothschild's agent in Madrid, to request 'a definitive order to the Director of Mines immediately to put the quicksilver he has ready on the road to Seville, whether on horses or on carts. The Director of Mines has no doubt

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Once delivered to the Atarazanas in Seville, the skins were checked for weight and leakages, and where necessary repacked before shipping downriver. Boxes were loaded onto small one-masted sailing boats (*tartanas*), characteristic of Seville, which set their course for San Lucar de Barrameda at the mouth of the Guadalquivir, and then south-east along the coast to Cadiz Bay. In 1839, ocean-going ships came up the Guadalquivir as far as La Costumbre, the highest reach where they could be loaded without running aground. By then they were supplied by steamers, but with *tartanas* the practice was probably current earlier.[41] Even at sea, the weight left boats at risk of grounding: in 1804, the *San Felipe Neri*, a *tartana* coming down from Seville with a cargo of 750 quintals of quicksilver packed in five hundred boxes, ran aground off the coast of Regla. She was relieved of 122 boxes before she could limp into San Lucar. These boxes were taken to the warehouses in Trocadero, while the rest were returned to Seville for repackaging.[42]

Before the French invasion, quicksilver sent down from Seville was unloaded and stored in Crown warehouses at Caño del Trocadero on the west side of Cadiz Bay.[43] The warehouses lay upstream, and the *tartanas* had to pass over hawsers, ropes and anchor chains, where big ships could run into smaller ones, capsize them and send the quicksilver to the bottom. The buildings were old and ramshackle; the roofs leaked; and the weight of the boxes made it impossible to store them on the rotten floorboards upstairs. Even on the ground floor the rain came through: in 1802

(n. 40 cont.)
been unwilling to send the consignment until he could do so on carts, for in this way the Government spends less . . . but please note that in the previous five years' contract [with Ezpeleta] the deliveries have never failed to arrive at the stipulated times, even with higher transport costs . . . He hasn't done so because he hasn't wished to do so . . . It is most urgent that you get the order mentioned, because any day now a boat from Bordeaux is expected in Seville, with the sole aim of taking on board 1,200 flasks sold by Sr. Rothschild, and if the cargo is unavailable who knows the damages and compensations that will be demanded by the buyer'.

[41] D. P. Anzoateguí to N. M. Rothschild & Sons, Seville, 23 Apr. 1839: RAL, Anzoateguí Correspondence.

[42] Juan Joaquín Moreno to Rafael Orozco, Isla de León, 7 May 1804: AGI, Arribadas 293, 'Oficios sobre transporte de azogues'.

[43] Trocadero was taken by the French on 5 February 1810. In 1823 the Place du Trocadéro in Paris was named to commemorate the second French victory there that year, during the second restoration of Fernando VII after the Liberal Triennium. These victories may have given French traders an edge in the quicksilver trade.

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the Director of Quicksilvers in the Caño del Trocadero ordered the boxes of skins to be covered with canvas sheets for their protection.[44]

Here, then, in these tumbledown warehouses amidst a tangle of shipping on the *marismas* (marshes) of the Andalusian Atlantic coast, were accumulated the boxes of skins, full of quivering metal, waiting to be sent to the American mines. After being weight-checked again and repackaged where necessary, boxes were issued with government authorization to the captains of ships bound for America. In the early 1800s the two jetties on the Caño del Trocadero were in such bad repair that quicksilver was loaded onto small dinghies in dry dock, which could be launched only with difficulty.[45] Once afloat, these ferried the boxes out to the big ships waiting at anchor in Cadiz Bay. The stevedores came across to Trocadero every day from Cadiz in a boat belonging to the royal consulate, returning for an hour at lunchtime, and coming over again in the afternoon before going back at night to sleep. They stowed the boxes in the dinghies and took them across to the waiting ships.

Loading boxes of quicksilver into an ocean-going ship's hold was a costly and time-consuming job, which often delayed a ship's departure. They were brought on deck following a routine which helped captain and shippers keep count; this continued into the age of flasks. In 1836 a captain alleged that eight flasks were missing from the four hundred that were supposed to have been loaded. Anzoateguí, Rothschild's agent, answered:

> When they are loaded the flasks are placed on deck ten at a time, and until they have been counted by the captain or the quartermaster of the ship and taken down to the hold, ten more flasks are not brought on deck; so you see there cannot be any mistake in these procedures.[46]

With boxes, carpenters were employed to construct wooden frameworks (*pañoles*) in the hold, to be dismantled and the timber sold in America. They were caulked, tarpaulined and sealed with tar, the boxes stacked inside to a maximum of five levels.[47]

[44] Josef Pizarro to Rafael Orozco, Caño del Trocadero, 19 Dec. 1802: AGI, Arribadas 293, 'Oficios sobre transporte de azogue'.

[45] *Ibid.*

[46] D. P. Anzoateguí to N. M. Rothschild, Seville, 3 Nov. 1836: RAL, XI/38/3–5, Anzoateguí Correspondence.

[47] Josef Pizarro to Rafael Orozco, Caño del Trocadero, 15 Oct. 1802: AGI, Arribadas 293, 'Oficios sobre transporte de azogue'. Before stacking, the general commander of the arsenal sent the master carpenters and caulkers to inspect the

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Crown warships also transported quicksilver, and because of their size were fitted out even more elaborately than merchant ships.[48] But in spite of precautions, with the jolts, shakings and ocean swells and storms, the quicksilver escaped, just as it had leaked out on the carts from Almadén and the *tartanas* from Seville; and that meant lower silver returns and illness among the crew.[49]

Table 3 shows the quicksilver sent to Lima between February 1802 and November 1803, with losses according to type of container. Out of a total of 9,930 quintals loaded, 30 quintals 62 pounds were lost: 30 quintals escaping from boxes of skins and 62 pounds mysteriously leaking from a flask (probably a problem with the stopper). It was such losses occurring all along the supply line from Almadén to the American ports, together with the thought of the silver ores left unrefined, quite as much as the dangers of quicksilver poisoning, that lay behind the Crown's interest in Josef Pizarro's proposal to replace boxes of skins with well-sealed iron flasks.[50]

(n. 47 cont.)
woodwork. Juan Joaquín Moreno to Rafael Orozco, Isla de León, 4 Feb. 1804: *ibid*. See also Gabriel Aminaraval to Rafael Orozco, Isla de León, 8 Jan. 1803, with copy of letter from Josef Pizarro, Director of Quicksilvers: 'The casing constructed in the Royal ships is better than that established in merchant ships. Besides having all their first joints caulked . . . they are covered with 1 or 1½ inch planks also caulked, and covered with canvas sealed with tar, which is finished with a general casing sealed with bitumen, so that it presents a tough surface through which not a single drop (*adarme*) [of quicksilver] can filter through': *ibid*.

[48] Josef Pizarro to Rafael Orozco, Isla de León, 8 Jan. 1803: AGI, Arribadas 293, 'Oficios sobre transporte de azogue'.

[49] Josef Pizarro, letter transcribed in Gabriel Aminaraval to Rafael Orozco, Isla de León, 8 Jan. 1803: AGI, Arribadas 293, 'Oficios sobre transporte de azogue'. Cf. Josef Pizarro to the Regency, Cadiz, 21 Apr. 1811: AGI, Indiferente 1785. Quicksilver poisoning was rife: in 1808 Josef Pizarro requested leave of absence to take the waters of Graena (Granada) to cure an 'attack of quicksilver, which is common in Almadén, Seville and this place, depriving me of the natural action of my hands and right leg'. Also Josef Pizarro to Miguel Cayetano Soler, Caño del Trocadero, 4 Mar. 1808. For health conditions at Almadén, see Alfredo Menéndez Navarro, *Un mundo sin sol: la salud de los trabajadores de las minas de Almadén, 1750–1900* (Granada, 1996).

[50] But flasks did sometimes leak. In 1846 a consignment of flasks was rejected by Rothschild's agent because they lacked the 'accustomed solidity' and some *salideros* (escapes) were noted, probably from faulty stoppers. D. P. Anzoateguí to N. M. Rothschild, Seville, 18 Mar. 1846: RAL, XI/38/3–5, Anzoateguí Correspondence.

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II

Josef Pizarro presented Valdés with his project in December 1788. He included a small sample flask full of 6 lbs of quicksilver, made by a Madrid blacksmith, together with a wooden model and a drawing. Pizarro proposed making twenty-four thousand flasks for carrying quicksilver between Almadén and Seville; eight thousand for Cadiz to receive any quicksilver arriving from Idria; eight thousand in transit to America; another eight thousand returning to Spain at any one time; and twelve thousand retained in the different ports of destination. This made a total of sixty thousand flasks.

Valdés gave the little flask to a scientific adviser at the court in Madrid, François Chavaneau, to examine in his laboratory of chemistry and physics. Chavaneau calculated the cost of each full-size flask at 60 *reales*, and estimated it would indeed last for 250 years, as Pizarro claimed. So in February 1789 Pizarro was invited to make between six and twelve trial flasks, each weighing 25 lbs, to be sent to the three viceroyalties of Peru, La Plata and New Spain.

The trial flasks were constructed in the royal iron foundries of La Cavada (Cantabria), and in May were sent by cart to the Basque port of Bilbao for dispatching to Cadiz. Only three flasks arrived; these were sent to Madrid, where Valdés again asked François Chavaneau to examine them; and Chavaneau's impressions were again favourable. So Pizarro was ordered to return to La Cavada and direct the construction of a set of two hundred trial flasks. A hundred of these were ready in December 1790, and were sent from Santander to Trocadero in May 1791. Twelve were retained by the president of Cadiz to receive any leakages that might occur in Trocadero (the stopper of one had rusted), while the rest were sent to the Commissioned Judge of Packaging in Seville for bottling the content of skins arriving from Almadén.

In March 1791 Pizarro proposed modifying the project by using wrought instead of cast iron, and sent his brother Miguel with two wrought iron flasks for inspection. These were approved by Chavaneau in April, although he favoured a square instead of a cylindrical shape so they could be stowed more compactly as ballast aboard the ships (see Plate). Finally, by royal order of 14 June

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TABLE 3
QUICKSILVER SHIPMENTS TO LIMA, 1802–1803: LOSSES BY TYPE OF CONTAINER*

	Quantity loaded in Spain	Quantity received in Lima	Loss
Warships			
Rufina	1,728 qq in flasks and boxes	1,726 qq	2 qq from boxes
Asunción	1,701 qq in boxes	1,689 qq 50 lbs	11 qq 50 lbs
Mercedes	1,500 qq in flasks	1,499 qq 38 lbs	62 lbs
Clara	1,500 qq in flasks	1,500 qq	None
Merchant ships			
La Paz	2,001 qq in boxes	1,999 qq 50 lbs	1 q 50 lbs
Dos Amigos	1,500 qq in boxes	1,485 qq	15 qq
TOTAL	9,930 qq	9,899 qq 38 lbs	30 qq 62 lbs

* Source: AGI, Lima 1334. Caja Real de Lima, 15 Dec. 1803. Manuel de Villar, Matrias de la Cuesta.

Key: q(q) = Spanish quintal(s) (1 Spanish quintal = 100 Spanish lbs).

1791 Pizarro was instructed to manufacture all sixty thousand flasks, making them square rather than cylindrical.

Pizarro first contracted with the count of Isla Fernández for the use of two drop-hammers (*martinetes*), thirty hand-forges (*fraguas de mano*) and other workshops, all in Pueblo de Marron, Vizcaya, for constructing the sixty thousand flasks there; and with Benito de Haro for the elaboration of sixty thousand iron sheets (*chapas*). However, the smelting work in Pueblo de Marron was done with fossil fuel in reverberating ovens, which produced too intense a heat; so Pizarro changed tack and contracted in the same terms with two neighbours from Eyvar (Guipuzcoa province), named Ybarzabal and Gabiola.[51] These ironmasters did the work with 'wood charcoal, which is gentler for this kind of hollow work (*obra hueca*) where the pieces must be welded together (*a caldas*) rather than soldered (*con soldaduras*)'.[52] Sixty thousand iron sheets were prepared in Eyvar, saving 25,000 pesos for the royal exchequer.

[51] For the neighbours from Eyvar, see Miguel Pizarro to Martin de Garay, Azpeitia, 10 Oct. 1817: AGI Indiferente 1785.

[52] Josef Pizarro to the Regency, Cadiz, 21 Apr. 1811: AGI Indiferente 1785.

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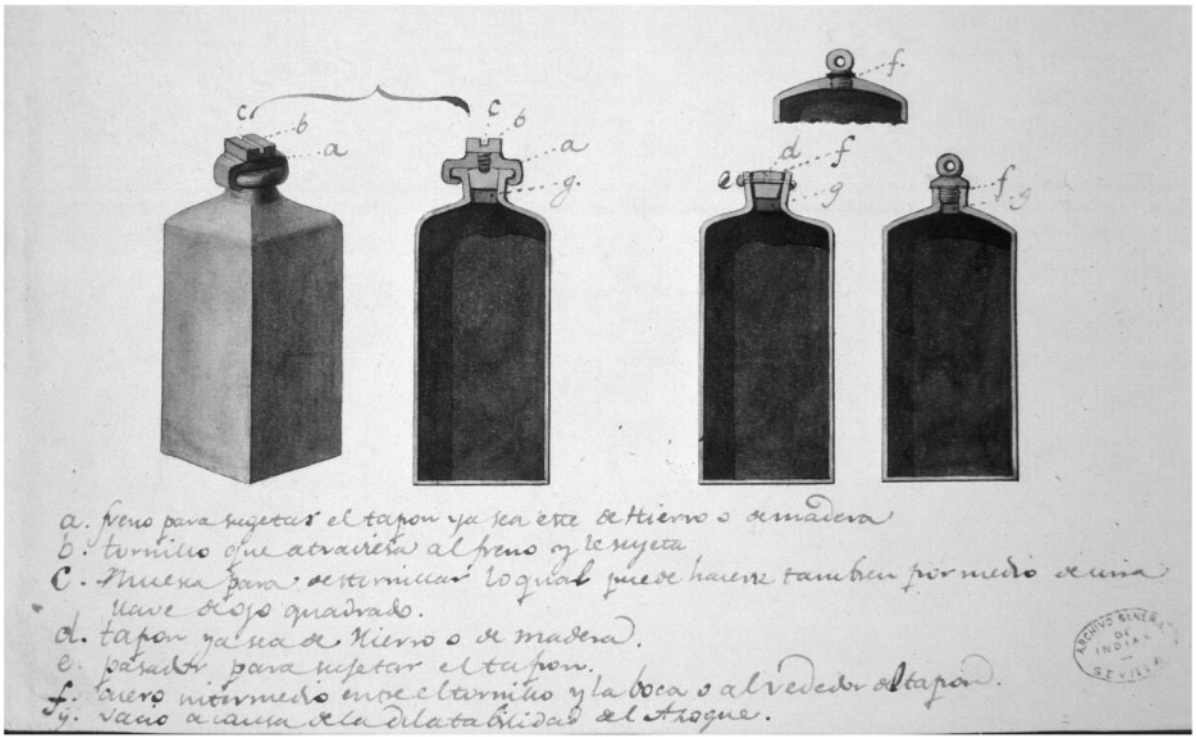
a. Freno para sujetar el tapon ya sea este de Hierro o de madera
b. tornillo que atraviesa al freno y le sujeta
C. Tuerca para asegurarlo lo qual puede hacerse tambien por medio de una llave de ojo quadrado.
d. tapon ya sea de Hierro o de madera.
e. casquete para sujetar el tapon.
f. taco de metal entre el tornillo y la boca o alrededor del tapon.
g. vacio o cama de la dilatabilidad del Azogue.

The iron flasks (1792). Source: Archivo General de Indias, Seville, Mapas y Planos, Ingenios y Muestras 75.
(For the text of the legend, see facing page.)

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But Pizarro had made a slip. He had changed contractors without governmental permission. Although the government did approve in the end, it ordered him to construct only ten thousand flasks, which — as well as any others to be constructed in future — should be by open contract. Pizarro was to advertise the contract in Vizcaya and the Montaña (Cantabria). The government was convinced that it was cheaper to put out contracts to private tender, rather than manufacture the flasks under the direction of Crown officials through 'administered production'. Market competition was seen as a means of cutting costs. Nevertheless, the contract work was still to be carried out under the supervision of Josef or Miguel Pizarro to specifications given by the government. The smaller number of flasks suggests that, no doubt as a result of the experts' contradictory opinions, the government was still uncertain about the benefits of Pizarro's invention.[53]

Pizarro answered on 11 July 1792 that, although he had ended the contracts with the count of Isla Fernández and with Benito de Haro, he could not break the contract with the technicians of Eyvar, as he had already paid for the workshops, tools and

[53] Jealous tongues, such as that of the president of Cadiz, don Bartolomé de Ortega, also claimed to have proposed putting skins inside iron containers to avoid leakages, 'which suggests that Pizarro's project is not new'. See 'Construcción de vasijas de hierro para la conducción de azogues', extract 4: AGI, Indiferente 1785.

Text of legend in Plate (left):

a. Freno para sugetar el tapon ya sea este de Hierro o de Madera.
b. Tornillo que atraviesa al freno y le sugeta.
c. Muesca para destornillar lo qual puede hacerse tambien por medio de una llave de ojo quadrado.
d. Tapon ya sea de Hierro o de Madera.
e. Pasador para sujetar el tapon.
f. Cuero intermedio entre el tornillo y la boca o alrededor del tapon.
g. Vacio a causa de la dilatabilidad del Azogue.

Translation:

a. Bracket to hold the bung, whether of Iron or Wood.
b. Screw which goes through the bung and holds it tight.
c. Groove by which to unscrew, which can also be done with a spanner.
d. Bung, whether of Iron or Wood.
e. Pin to hold the bung.
f. Leather between the screw and the mouth, or around the bung.
g. Empty gap in case the quicksilver expands.

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materials, and had at his disposal sixty thousand finished screws, as well as flask tops and bases and some 28,000–30,000 main sheets of iron, together with seventy-six active workmen. But on 29 July 1792 the royal order was repeated. Pizarro was reprimanded and told to advertise the new contract for not more than ten thousand containers, and to compensate any prejudice to the Eyvar contractors under the supervision of the governor of San Sebastián.

However, the government was still undecided. On 23 August, the idea of contracting out ten thousand containers was suspended, and Pizarro's original contractors in Eyvar were ordered to finish that number of containers. The contractors and Pizarro protested because many more containers were under construction. So in September they were told to construct the other fifty thousand in their own time, and to send the ten thousand, as soon as they were ready, to Cadiz and Seville. There they would be filled with quicksilver for shipment to New Spain; the Mexican viceroy was to inspect them on arrival to determine their quality, and how they could be returned to Europe without cost to the treasury. At the end of December, Pizarro wrote that he had loaded 8,400 containers; but he was told to hold them because they had not been varnished inside to protect them from 'amalgamation' (see next section), and so were 'causing new costs'. In April 1793, Pizarro wrote that all flasks had been unloaded and stored because of war with France.

Finally, on 11 June he was ordered to suspend construction because the faculty members Ricarte, Cosme Bueno and Angulo had decided to impugn the flask project. But 43,482 had already been built, and only 16,518 more were needed to complete the sixty thousand originally projected. With the work suspended, a commissioner, don Miguel Basterra, arrived in Eyvar and inventoried the finished containers. He recovered a total of 46,858 flasks ready for embarkation, observing that the device for inserting and extracting the screws for the tops was indispensable.[54] He sent one container to the seminary at

[54] For drawings of Pizarro's devices for opening and closing the flasks, see Miguel Pizarro to Diego de Gardoqui, Eyvar, 9 Dec. 1792: AGI, Indiferente 1784-A, fos. 802^{r}–803^{v}, 909^{r}–910^{v}; plates also catalogued as AGI, Mapas y Planos, Ingenios y Muestras 73, 73 bis, 74 and 75 (see Plate in this article). A simple screw method was described by Juan Pizarro in a letter to Rafael Orozco from Cadiz, 16 Aug. 1811. A set of flasks 'must be tested with quicksilver [to see if they leak], using what

(cont. on p. 231)

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Bergara, where the opinion was that rust would not affect the quicksilver; the shape was good (though cylindrical would be better); the containers would indeed last 250 years; that with a little oil the screw-tops could easily be opened and closed, using Pizarro's device; and that there was no danger of them bursting with the high temperatures of the tropics, because for that to happen the quicksilver would have to reach a state of incandescence. These opinions reveal something of the caution prevailing among the experts.

In the end, Basterra was able to send 46,700 iron flasks from Santander and Deva to Ferrol (Coruña). Charges were brought against Pizarro, who in February 1795 was unavailable to make a declaration, apparently because of a new malaria attack; but he made a written defence against every charge. It was not until June 1798, nearly *ten years* after presenting his first proposal, that he was finally exonerated of all charges.

So, in 1799 Josef Pizarro finally got his post in Andalusia: he was named Director of Quicksilver Packaging in the Crown warehouses at Trocadero on Cadiz Bay; and his brother Miguel was commissioned to take up the construction of the flasks. Miguel went to Vizcaya to re-establish the factory accompanied by his two sons Pedro Miguel and Josef Antonio. He based himself in Azpeitia and set about having another fifty thousand flasks constructed. After so many vacillations, the Madrid government had finally taken a decision: brother Miguel was put in charge of the manufacture of the flasks in Vizcaya, and brother Josef was appointed to receive them in Trocadero as they came down full from Seville. The project of the iron flasks had entered a more promising phase.

(n. 54 cont.)
is available in the existing boxes; the neighbouring storehouse will be necessary to store them in, as there is not enough space to examine them properly otherwise; an iron clamp [will be needed] to hold them while opening and closing them, two crank-levers to screw and unscrew them, a clay funnel to fill them with, four hooked crowbars to manipulate them with when full, and a pair of two-pound hammers to tap loose any metallic flakes and rust . . . and finally a post of wood about two yards long to drive into the ground for the iron clamp to be nailed to . . . not to mention the labourers needed to carry out the examination satisfactorily': AGI, Arribadas 293.

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III

Let us pause to consider briefly the views of the faculty members who rejected the flasks: François Chavaneau, Josef Ricarte, Pedro Gutiérrez Cosme Bueno and Angulo. All were eminent scientists of their time, and Josef Ricarte had been awarded a scholarship to go to Freiberg and study the 'new' central European methods of amalgamation. The choice of materials and design for the flasks was judged in relation to current metallurgical knowledge, which was in a state of flux. Pizarro's first model flask was produced only a couple of years after Born had recovered Alonso Barba's hot method of amalgamating silver ores in copper cauldrons.[55] Both copper and iron had been used in America since the sixteenth century as reagents during amalgamation, and it was known that quicksilver could amalgamate with copper, tin, silver, gold and other minerals. The comparison between copper cauldrons and iron flasks was inevitable, for the extent of quicksilver's powers, as well as its combination of poisonous and medicinal qualities, were still imperfectly charted by Europe's 'new chemistry'.

Designing a container was thus a problem of theoretical as well as practical complexity. The choice of iron worried those scientists who lacked American experience with amalgamation and were insufficiently acquainted with what was transpiring in central Europe. So, although Chavaneau had earlier been in favour of the project, in 1793 the committee pronounced against it. Their doubts were mainly concerned with the suitability of iron and its relations with quicksilver, the way the iron was to be worked, the shape and size of the flask, and the design of a suitable stopper. None of them could offer guidance in industrial design (apart from Chavaneau's suggestion that they be made square, not cylindrical); and in the end 'the business was suspended, several faculty members who were consulted having declared against it,

[55] Born's 1786 book retained the German chemist Georg Ernst Stahl's 'imagined concept' of phlogiston as the combustible element in matter. It was published a year before the *Méthode de Nomenclature chimique* (1787), in which Lavoisier and a group of French chemists replaced the idea of phlogiston with that of oxygen. Although rejected at first in Germany, a Spanish summary of the *Méthode* was published in 1788, the year of Josef Pizarro's proposal, by Cosme Bueno.

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and who unfortunately had this motive for manifesting their lack of preparation in the subject'.[56]

Cosme Bueno was clearly fearful of the possibility that quicksilver might amalgamate with iron. He cited an obscure experiment which had involved mixing a little lime or iron oxide with quicksilver in a mortar; after grinding it for several days the chemist had noticed a few atoms of 'amalgamated iron'. But the chemist was unknown and the experiment had not been repeated. Nevertheless, Cosme Bueno had raised a doubt which had to be dispelled.[57]

In answer, Josef Ricarte considered that, even if the experiment with the mortar were genuine, inside the flasks there would be no grinding or friction, only gentle contact between the quicksilver and the iron, so it was unlikely that amalgamation would occur. He cited practices observed in Austria-Hungary: experts such as Born, Ruprecht and Fausto de Elhuyar had all used quicksilver previously amalgamated with silver in iron tubs just as confidently as they had used quicksilver in leather skins fresh from Idria. Ricarte added that, in the early versions of the 'Freiberg method', the barrel had been made of cast iron, and that wooden barrels had not been adopted because of any ill effect on either the iron or the quicksilver. In fact, central European refiners added six to eight plaques of iron to the mixture in each barrel, and they still used the quicksilver afterwards for fresh amalgamations, replacing the amount consumed. The only problem might be the formation of a thin skin, or crust, inside the flask, without the liquid quicksilver being affected.

Ricarte here compared the known effects of quicksilver on copper: in Alonso Barba's cauldrons, a little quicksilver amalgamated with the copper surface of the cauldrons, at the same time as most amalgamated with the silver, building up a crust so hard that it took a wire brush, and sometimes a hammer, to

[56] Doc., n.d. [1806?]: AGI, Indiferente 1783. The only surviving flask I have seen, in Almadén, is cylindrical, not square.

[57] Pedro Gutiérrez Cosme Bueno (1711–98) was the author of geographical descriptions of various American provinces, and from 1758 held the post of Royal Cosmographer of the Viceroyalty of Peru. Member of the Medical Society of Madrid from 1768, he became a member of the Basque Society in 1784. By 1788, when he published his Spanish summary of the *Méthode de Nomenclature chimique*, he was professor of chemistry at the Royal Laboratory in Madrid. See Maurice P. Crosland, *Historical Studies in the Language of Chemistry* (London, 1962), 211.

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get it off.[58] This crust formed while allowing only traces of copper to pass to the silver amalgam forming in the cauldrons. With iron flasks the effect would be less; the inside could be swilled with a lime or clay wash, or with varnish, or with the black paint used to stop iron rusting; and a film could be placed between the quicksilver and the iron.

In the end, Chavaneau, Ricarte and Angulo pronounced that Cosme Bueno was wrong, and that there was no risk of the iron damaging the quicksilver. However, they decided that the flasks should be made of cast, not wrought iron, 'which is an idea opposed in its concept to that held when Pizarro was ordered to construct sixty thousand flasks of wrought iron as being more useful than those made with cast iron'. This difference determined the project's suspension. Ricarte himself preferred flasks of glass, such as were used in Idria, each wrapped in grass matting like a Chianti bottle, and then placed in boxes with wooden cavities, like those used for beer-bottles.

Unlike the scientists, Josef Pizarro (who had spent a year in America) was clear on the reasons for his choice of iron, and his practical arguments eventually won through:

> The nature of quicksilver, its declared enmity with human nature, its weight and extraordinary fluidity, greater than that of any other material, which even the most solid bodies cannot resist, made me direct my attention — after many experiments, amalgams and analyses — towards iron, having observed that quicksilver, although it pulverizes all known metals, is in contact and good harmony with iron, on which it makes no dent nor do they mutually destroy each other.[59]

IV

In 1799 Miguel Pizarro took up residence in Azpeitia, Vizcaya. He set about constructing another fifty thousand flasks; and then presented a plan to construct fifteen thousand per year, for which contractors were invited to tender in Madrid. In March 1800 the royal finance ministry accepted an offer by the same two neighbours from Eyvar, Ybarzabal and Gabiola; but in May they cancelled it due to a better offer from Aguirrebeytia of Durango; and

[58] 'Construcción de vasijas de hierro para la conducción de azogues', extract 3º, 'Realización del Proyecto. Comisión a Pizarro para la construcción de 60D. Dictamen de varios Químicos sobre dichas Vasijas. Contratas con los Fabricantes: reclamaciones de éstos, &ca.': AGI, Indiferente 1785.

[59] Josef Pizarro to the Regency, Cadiz, 12 Apr. 1811: AGI, Indiferente 1785.

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this second contract was in turn cancelled because the contractors of Durango could not match a still lower offer by Pedro Allaneguí, an ironmaster from Azpeitia, of 36 *reales* and 3 *cuartillos* for each flask weighing 17 lbs. A contract was signed with Allaneguí on 28 May 1801, and continued until 1805, when the contractor died after putting at least sixty thousand flasks into circulation.[60]

The government wanted the work continued by private contractors, and invited the Royal Philippines Company to let out the contracts, offering to reimburse their credits through discounts on their trade in America. Reluctant at first, the Company was tempted when offered an annual contract for thirty-three thousand flasks, sufficient to carry 24,750 quintals from Almadén to America; and their counter-proposal of making thirty thousand for one trial year, to be paid for in Mexico, was accepted by the government and by Miguel Pizarro.

The Royal Philippines Company then authorized José María de Lardizabal of San Sebastián to agree procedures with Pizarro. Advertisements for contractors were posted, and four proposals were received and sent to the government in July 1806. Pizarro insisted that it would be cheaper for the Treasury to build the flasks under the administration of Crown officials, although his own estimate was 65 *reales* per flask. The Company preferred the proposal of two ironmasters from Iraeta, Antonio Francisco de Echeverría and Manuel de Arambarri, whose price was 50 *reales* per flask. Echeverría and Arambarri accepted all the conditions agreed by the dead contractor, Allaneguí, and did not ask for any advance. Faced with competing offers, Echeverría and Arambarri lowered their price to 48 *reales*, offering to construct thirty-three thousand during 1807 and demanding the preference because of their previously successful bid.

Arambarri and Echeverría finished their contract on 4 December 1807 with thirty-three thousand flasks constructed, and reported that their factories were stationary and the workers dispersing, while no new contract had been advertised. They offered to continue their contract during 1808, raising production to forty thousand flasks, each weighing only 14 pounds empty and with a capacity for 30,000 quintals of quicksilver (at

[60] The information in this section comes mainly from AGI, Indiferente 1785, esp. no. 40, 'Extractos de los antecedentes que acompañó la Secretaria a la exposición de D Miguel Pizarro de 10 de octubre de 1817'.

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75 pounds per flask). They asked to receive their payment in Barimas and Curaseca tobacco at 340 *reales* per quintal, or else in cash payable in Caracas. Time was running out if enough flasks were to be available for the following year, particularly as skins were no longer being sent to Almadén. The government therefore approved the proposal, and a new contract was signed on 8 January 1808.

By April 1808 Arambarri and Echeverría had finished 14,651 flasks, when their contract was violently interrupted by the French invasion of Spain. Materials worth 506,448 *reales* had been accumulated in the workshops, but their operations were suspended without compensation by the Central Junta due to 'the change in the circumstances'. It would be another eight years before they were asked to fulfil the remaining part of their contract.

V

The story of quicksilver shipments to America during the Peninsular War of Independence against the French is one of a collapse in production; of recourse to free trade from 1811 to facilitate trans-Atlantic transport during the French occupation; of the search for alternative sources and markets across the world, including the dispatch of an emissary to Manila in search of Chinese quicksilver; of top-secret plans for a sudden raid on Almadén, formally in French hands, to recapture quicksilver accumulated there; and of a dramatic undercover mission carried out by Miguel Pizarro, at the request of the Cadiz Regency, to save thousands of iron flasks stuck in Northern Spain, and then ship them round Portugal from San Sebastián to Cadiz, Seville and — eventually — Almadén. All this was in the context of a brutal, bloody occupation and a bitter war of resistance.[61]

In 1810 the French advanced south to Cadiz Bay and took Trocadero, forcing the relocation of quicksilver stocks to the peninsular fortress of Cadiz. The French were as keen as the Spanish to ensure a continuing flow of silver from the Americas in order to facilitate trade, although they intended to control the quicksilver

[61] For the suspension of production at Almadén, see Figure above; Dobado, 'Las minas de Almadén'. For Spanish diplomatic relations with China, see AGI, Indiferente 1783, 12 Dec. 1812.

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and return trade with the American ports themselves. Still, there was a basis for negotiation. Although the French named their own governor of Almadén, he remained in Madrid, probably more involved with negotiating sales than with the day-to-day operations at the mine, which continued in the hands of Spanish officials.

These had a difficult task. Skins were scarce, and there was a chronic lack of transport from Almadén to Seville. Carts could be requisitioned; but in Cadiz a plot was hatched to get one of the Spanish armies of defence to conduct a raid, while English traders and the Cadiz Chamber of Commerce competed to negotiate, with the agreement of the French, an exchange of quicksilver for supplies and cash to pay and feed the workers and keep the great mine in production. To speed up the transport to America of any quicksilver available, a formal end to the Crown monopoly was decreed on 11 January 1811, which legalized transport by foreign powers, although the Regency continued to keep the price for Crown supplies low, thus undercutting and restraining for a time the rampant speculation that would occur once subsidies finally ceased in the early 1820s.

But to restore the production and export of quicksilver from Almadén, more flasks were needed, and the services of the Pizarro brothers were again sought. On 15 July 1809, with the Basque provinces occupied by the French, Miguel Pizarro was ordered by the Central Governing Junta in Seville to return to Vizcaya to get the flasks corresponding to the last two contracts, now stored in San Sebastián, and 'free them as best he may from the power of the enemies'. Pizarro was instructed to send back reports in confidential letters to his sons, and left Cadiz in a boat destined for San Sebastián.

With the French invasion, all property belonging to the Spanish state had been appropriated by the invaders, although private property was nominally respected. Some individuals — 'who are only interested in being the ruin of their brethren' — had told the French general that the thirty-three thousand flasks constructed in 1807 had been paid for and hence belonged to the state, while 14,651 flasks constructed as part of the contract of 1808 were still unpaid, and hence remained the property of the contractors. Pizarro managed to get the 14,651 legally assigned to Arambarri and Echeverría and all 47,651 delivered to the freight judge in San Sebastián. In his report he asked for a royal order

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stating that the 14,651 flasks were the property of the contractors who had not been paid; and he proposed a military solution to the problem of the remaining thirty-three thousand, which was rejected when Spanish commanders could not agree.

On 10 September 1810 Pizarro was again sent to collect fourteen thousand flasks from the stock in San Sebastián, namely the flasks assigned to Arambarri. Freight charges had rocketed with the invasion, and whereas previously it cost 10–12 *reales* to send a quintal of iron to Cadiz, it now cost more than 30 *reales*. So Pizarro asked for 60,000 *reales* to carry out his commission. But the task was still impossible, as the French controlled San Sebastián. Pizarro's last commission was not given until August 1813, when Spanish and British forces were laying final siege to the port.

The scene that unfolded can be glimpsed through contemporary descriptions. By early September the Spanish and British forces had taken most of San Sebastián, but the French held out from the Castillo above the city, raking the town square with bullets. All around buildings were on fire, with masonry crashing to the ground in rubble. The flasks were hidden in a vault beneath the town square, buried under piles of stones following the conflagration that had left most of the city in ruins. When the French finally surrendered on 8 September, the Spanish intendant advised Pizarro, who with his son had located the flasks, to wait until the British had left and Spanish troops had taken control of the town. The flasks were seen as a state secret, to be shielded from the eyes of other nationalities; there was distrust of what British troops might do with the flasks if given half a chance.[62]

Meanwhile, Pizarro requested soldiers from the general headquarters in Irún to help disinter the flasks and get them on board a boat to Cadiz, since otherwise the task would take 'more than four months'. The reply from the commanding general Antonio Garcés was that funds were scarce, and his first priority was to repair the fortifications of the city.[63] If soldiers were to be used (Pizarro needed sixty or seventy men), each would have to be paid

[62] Miguel Pizarro to the Finance Ministry, Irún, 21 Sept. 1813: AGI, Indiferente 1785.

[63] Manuel Preyre to Miguel Pizarro, Cuartel General de Irún, 1 Oct. 1813: AGI, Indiferente 1785.

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3 *reales* 22 *maravedís* per day.[64] At this point Pizarro met with a 'gentleman merchant' of San Sebastián who, learning of the order given to Pizarro by the Regency and the position taken by the military commander, offered to lend Pizarro 6,000 *reales* without interest, on condition that he would be repaid in Cadiz once the flasks were unloaded there. This solution by 'one of the few good patriots' enabled Pizarro to contract boats, to be paid for in Cadiz, 'if the generals and intendants have none to spare'.[65]

On 17 December Pizarro reported that he had extracted the fourteen thousand flasks, and another six thousand as well, although work was still threatened by the collapse of the remaining walls, further weakened by winter storms now battering the calcined masonry. Disease had spread from unburied rotting bodies, shelter was scarce and food supplies scanty. Still, Pizarro promised to continue extracting flasks until he had retrieved the whole 47,500, at which point he realized that they had not been varnished! Remembering, perhaps, the distant problems of December 1792, the repeated insistence of the academics and the terms of the contracts awarded, Pizarro decided to varnish only the fourteen thousand ordered for Cadiz, as the cost of linseed oil had also spiralled.[66] Somehow Pizarro's mission eventually succeeded, and with 47,500 flasks at its disposal the government had packaging for more than 35,500 quintals of quicksilver. Supplemented by boxes of skins, this was enough for a couple of years.

But by 1815 Ferdinand VII was back on his absolutist throne, waging war in America against a motley front of liberal republicans, constitutional monarchists, Inca restorationists, and Creole, mestizo and Indian guerrillas. Moreover, it was a key assumption of late Bourbon colonial policy that the loyalty of the colonies depended on a regular supply of cheap quicksilver.[67] Without it, miners and merchants might become disillusioned: silver production would cease and Atlantic trade might seize up.

[64] Antonio Garcés to Miguel Pizarro, San Sebastián, 5 Oct. 1813: AGI, Indiferente 1785.

[65] Miguel Pizarro to the Finance Ministry, San Sebastián, 10 Oct. 1813: AGI, Indiferente 1785.

[66] Miguel Pizarro to the Finance Ministry, San Sebastián, 10 and 17 Dec. 1813: AGI, Indiferente 1785.

[67] AGI, Lima 1357. In a letter to the viceroy of Peru on 18 October 1802, Miguel Cayetano Soler had argued memorably that Spanish control of quicksilver supplies would stifle desire for independence among Peruvians.

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The Cadiz merchants, traditionally dependent on the arrival of American silver, had therefore taken upon themselves the loyal task of sending flasks of quicksilver as ballast in troopships organized and fitted out by the Junta de Reemplazos (Council of Replacements); the troops were to be paid with the income from quicksilver sales.[68] Evidently, new measures had to be taken to ensure a regular supply of flasks for the coming years, as the Spanish king, free at last from the French, made a final bid to recover his American kingdoms.

VI

Already in 1814, following the recovery of the flasks from San Sebastián, Pizarro had tried to capitalize on his success by presenting a new plan to the government for producing more flasks. The government at first approved (royal order of 1 March 1815), and Pizarro was appointed commissary marshal. The idea was to advertise the construction and have the contractor supervised by government experts, namely Miguel and his son Pedro. But in 1816 the government found itself without any flasks to hand, and no way of collecting over 20,000 quintals of quicksilver accumulated in the sinks at Almadén. There was no time to resort to public advertisement: inscriptions, bids, acceptance, notarial registration, guarantees and preparation of the factories, would mean six months' delay. So, on 26 January the pre-war contract with Arambarri and Echeverría was revived: the construction of 25,349 flasks was still pending. The only modification was that the contractors now asked to be paid in quicksilver at 696 *reales* per quintal; once that was accepted, they 'offered to put their hands to the task at once'.

In August, the contractors informed the government that the required number of flasks would be ready in October; but to avoid

[68] See 'Correspondencia de la Comisión de Comercio con los Consulados de America': Archivo Histórico Provincial de Cádiz (APC), Sección Hacienda, Varios 176. The Junta de Reemplazos was set up in 1812 to send out troop reinforcements, and in 1813 it adopted a suggestion from the Lima Mining Tribunal that troops could be paid from the sale in America of quicksilver carried as ballast in the troopships. Cf. A. Matilla Tascón, 'Las expediciones o reemplazos militares enviados desde Cádiz a reprimir el movimiento de Independencia de Hispano-América', *Revista de Archivos, Bibliotecas y Museos*, lvii (1951). But the prices soon reached the market rate, much higher than the miners were accustomed to, and the Lima Mining Tribunal begged for more to be sent, but not in the troopships.

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disbanding the labour force and wasting materials, they offered to construct another twelve thousand as part of the existing contract, thus allowing the next contract to begin in the following year. This was accepted in spite of Miguel Pizarro's protests, as otherwise there would not be sufficient flasks to package more than 23,000 quintals already distilled and waiting in the sinks at Almadén. On 31 March 1817 Arambarri and Echeverría announced that all the flasks were ready; they proposed to continue manufacturing at the rate of twenty-five thousand flasks per annum, charging 45 *reales* per flask, instead of 48, to be paid in quicksilver. This was equivalent to an annual income of 1,125,000 *reales*, the value of over 1,616 quintals of quicksilver.

The contractors' report was examined by the governor of Almadén and by the Director of Public Credit who, after comparing it with the conditions demanded by the secretariat, approved the conditions; and on 22 May 1817 the governor of Almadén was ordered to sign a written agreement to provide quicksilver for 125,000 flasks over five years. Miguel Pizarro and his son were left in limbo, with all their papers misplaced. Indeed, it was not until 1823, when Fernando VII returned yet again to the throne at the end of the Liberal Triennium, that Pizarro made a final attempt to gain royal recognition for himself and his son. For the last time he traced the tortuous history of the iron flasks, from the days of Valdés and Chavaneau to the French wars and their sequel. The Crown's answer, if there was one, is not in the file; but by now the flasks had taken a road of their own, leaving their inventors behind.[69]

By the 1820s iron flasks were used in most of the quicksilver trade, although skins had not disappeared completely. As late as 1838, when the Rothschilds' first contract with the Crown was coming to an end, we hear of skins of quicksilver stocked in the Seville Atarazanas, presumably sent down from Almadén.[70] Skins were still available as a fallback, it seems, when flasks were scarce, but were no longer accepted in international consignments.

[69] Miguel Pizarro to Juan de Erro, Azpeitia, 20 Oct. 1823: AGI, Indiferente 1785.

[70] In May 1838, Anzoateguí wrote that there were 1,621 flasks and 969 boxes of skins in Seville; two weeks later we hear that the quicksilver in skins would be transferred to flasks before it was sent downriver. D. P. Anzoateguí to N. M. Rothschild, Seville, 12 and 30 May 1838: RAL, XI/38/3–5, Anzoateguí Correspondence.

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VII

So, returning to the problem expressed in my epigraph, were flasks more economical than boxes of skins? Or were they a modern innovation — convenient and eventually indispensable, but bringing with them an overall rise in prices? Some argued, as we have seen, that quality of manufacture ('perfection') was more important than price, for only a high-quality product could prevent leakages. Quicksilver prices *did* rise dramatically in the 1820s, as Crown protection fell away, leaving supply in the hands of French speculators — though only a few pesos of the increase should be attributed to the flasks. We can start by asking whether flasks were cheaper to use than boxes and skins, a question that Spanish accountants addressed in 1807 by comparing the costs of packaging a single quintal of quicksilver in skins and in flasks (see Table 4).

How is this table constructed? How did the accountants calculate the costs per quintal? On the side of the skins, the first cost consists of the salaries of all those employed in Seville and Trocadero, as well as of the Inspector of Skins in Madrid (totalling over 100,000 *reales*), which work out at 4 *reales* 10 *maravedís* per quintal of quicksilver packaged in boxes of skins. Then there are the costs of the actual skins (13*r* 1*m*); of their transport from Madrid, their packaging with quicksilver in Almadén, and their transport to Seville (24*r* 12*m* in all); of repackaging with more skins in Seville and transport to Trocadero and the ship (21*r* 33⅓*m*); and of the wooden stacks in the ship's hold, the losses from leakage, and the excesses from overpacking which never reappeared in the accounts (22*r* 5⅝*m*). The total per quintal packed in skins comes to 85*r* 28⅛*m*, and there is a deduction of 5*r* 23*m* for the sale of skin scraps, so that the final cost per quintal is 80*r* 5⅛*m* 'in the ship's hold'.[71]

On the side of the iron flasks, the cost of each flask (plus that of an additional third of a flask — that is, 25 lbs — because a flask carried 75 lbs of quicksilver, and so a quintal of 100 lbs needed 1⅓ flasks) is put at 64 *reales* (corresponding to 48*r* for 75 lbs capacity, precisely the price charged by Arambarri and Echeverría in 1807). The flasks had then to be transported from San Sebastián round Portugal to Cadiz, and from Cadiz via Seville to

[71] Though the contemporary accountants rounded off some totals and made minor mistakes in others: see notes to Table 4.

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Almadén, before they could be filled and carted back to Seville, shipped from Seville to Trocadero, and ferried to the ship. The overall cost of transport, filling, packaging, and paying the warehouse guards amounts to 35*r* 10⅔*m*, which is significantly lower than for skins; but the initial cost of a flask was almost five times higher than its equivalent in skins. Consequently, the cost 'in the ship's hold' of a quintal of quicksilver packaged in iron flasks comes out at 99*r* 10⅔*m*, almost 20 *reales* more than that of the same amount packaged in skins — even including the savings from stopped leakages which had been the original impulse for Josef Pizarro's brainchild.

Nevertheless, the accountants still managed to assign a cost advantage to the iron flasks by including the profits to the Crown of selling the iron in America, and they contrasted this profit with the value of skin scraps sold after transporting quicksilver in boxes of skins. Certainly, iron as well as quicksilver had long been a vital mining input, imported to America from the peninsula. As Josef Pizarro put it in a letter to the president of the Regency in April 1811:

> Supposing that all the quicksilver packed so expensively in skins arrives in America, in those destinations what use to the king are the cords (*valdanas*), boxes (*barrilillos*) and grass mats in which they are wrapped? Obviously nothing. And the flasks? The flasks, as they are made of iron, which is in such demand there, are sold by the king to the miners, charging double or more what they cost in Spain, on terms which makes it more worth his while always to be making new ones than to be returning them to be used two or three times, as they very well could if they were looked after properly; so it can be concluded that it costs the king nothing to send quicksilver from these kingdoms to those without losing any as he did before; on the contrary he profits from the trade in iron.[72]

In Mexico, it was agreed that flasks should be sold to the miners; and after much debate the price was fixed at 15 pesos per quintal, or 3 *reales* per pound, which, if the weight of each flask was put at 17½ pounds, would come out at 52*r* 17*m*, when considered as raw iron. This is precisely the resale value (4½*r* more than the cost in Spain) placed on the flask by the Spanish accountants. It enables the total cost per quintal of quicksilver (in 1⅓ flasks) placed in the ship's hold to be reduced to 29*r* 10⅔*m*, assuming that this advantage over boxes of skins would be realized when the flasks were resold to American miners (see Table 4).

[72] Josef Antonio Pizarro to the Regency, Cadiz, 21 Apr. 1811: AGI, Indiferente 1785.

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TABLE 4

COMPARATIVE COST IN 1807 OF 1 QUINTAL OF QUICKSILVER IN CAÑO DEL TROCADERO, BY PACKAGING*

Packaged in skins		Packaged in flasks	
Salaries of employees in Seville, Trocadero and of Inspector of Skins (Madrid)	4*r* 10*m*	Wages of warehouse guards in Seville and Trocadero	0*r* 11⅓*m*
Cost of skins	13*r* 1*m*	Flask of 3 *arrobas*, plus 1 *arroba* to complete quintal	64*r* 0*m*
Transport of skins etc. from Madrid to Almadén	4*r* 29*m*	Transport of flasks from San Sebastián to Cadiz	1*r* 22*m*
		Transport of flasks from Cadiz to Almadén	5*r* 24*m*
Packaging in Almadén, and transport of packaged quicksilver from Almadén to Seville	19*r* 17*m*	Packaging, wicker baskets and ropes to load on cart for transport from Almadén to Seville	1*r* 15*m*
		Transport from Almadén to Seville	23*r* 6*m*
Repackaging in Seville, skins and their transport from Madrid to Seville, day wages, transport from Seville to Caño del Trocadero	21*r* 27*m*	Transport from Seville to Caño del Trocadero	2*r* 28*m*
Transport from Trocadero to ship	0*r* 6⅓*m*	Transport from Trocadero to ship	0*r* 6⅓*m*
Wooden fittings in ship's hold (1804)	11*r* 17*m*		
Loss from leakage in transit	9*r* 4⅓*m*		
Loss from excess packaged	1*r* 18½*m*		
TOTAL	85*r* 28⅙*m*[a]		

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Deduction for sale of skin scraps	5*r* 23*m*		
TOTAL cost per quintal in ship's hold	80*r* 5⅙*m*[b]	TOTAL cost per quintal in ship's hold	99*r* 10⅔*m*
		Deduction of value of flask, to be sold to American miners at 52½*r*	70*r* 0*m*
		FINAL cost per quintal after sale of flask	29*r* 10⅔*m*

* Source: AGI, Indiferente 1783, 17 Nov. 1807.

Key: *r* = *reales*; *m* = *maravedís* (1 *real* = 34 *maravedís*).

[a] The accountants wrongly make the total 85*r* 18*m*.
[b] The total is my correction of the accountants' total of 79*r* 29*m*.

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However, this assumption is problematic. First, the quality of the iron used for constructing the flasks was too high, 'for it is more fired, purified and hammered than *Bergajon* or *Platina*, which are the irons usually found in the market'. The flasks were constructed with cylinders, much appreciated for locksmiths' work, though also for some mining tools. It was suggested that they might be priced as raw iron,[73] but I have found no reference in Bolivian archives to flasks as a major source of iron in early Republican Potosí. On the contrary, we read that other iron objects were easily available: ready-made crowbars and tools were for sale in the Credit Bank of Potosí in the 1830s, for example; and, in the 1850s, Potosí import houses were advertising other forms of iron (Swedish iron for ladles as well as Basque crowbars).[74] The question deserves examination in different parts of the American mining world.[75]

Moreover, for early Republican Potosí it is unclear whether the resale value of flasks was incorporated into state accounts. The National Mining Bank's accounts show prices per quintal, without any visible charge for the iron flasks containing the quicksilver. Perhaps the value of the flask is included in the price per 75 lbs of quicksilver; or were miners bringing their own containers to the bank to avoid loading themselves up with more and more iron flasks? Was the iron indeed too pure for manufacturing mining tools (hence the import of ready-made crowbars from Vizcaya)? One entry states that the bank had thrown in the iron flasks free as a subsidy to the miner.[76] Again, practices will have varied across the Americas.

[73] 'Los Virreyes de Nueva España y del Perú se han declarado . . .': AGI, Indiferente 1783.

[74] Archivo Histórico de Potosí, Bolivia, Escrituras Notariales 360, 29 Oct. 1836. The entry shows Viviana de Uzín, widow of the wealthy miner and first Republican governor of Porco Province (Potosí), Leandro de Uzín, mortgaging her house to the Credit Bank of Potosí as security for 300 pesos, 2 quintals of tools, 3 crowbars, 1 tambor of coca and 1 quintal of grease. Coca leaf was a basic input provided by mine owners for workers' consumption: it was taken ceremonially and helped miners resist the high altitudes.

[75] For example, there is a reference to the use of iron flasks (clearly cylindrical) as tubes for making cannon barrels in 1810 among the artillery of the Mexican insurgents: see Eder Antonio de Jesús Gallegos Ruiz, *Del bastion realista a la inventiva insurgente: tecnología artillera y paisaje novohispano, 1762–1815* (Univ. of Veracruz, Xalapa, thesis of *Licenciatura*, 2011).

[76] Archivo Nacional de Bolivia, Sucre, Ministerio de Hacienda, Prefectura Potosí Recibidas (hereafter ANB, MH PPR). The Potosí Mining Bank's accounts show

(cont. on p. 247)

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So the flasks were not always the trouble-free solution that Josef Pizarro had hoped for in 1788. In Potosí, during the first Republican decades, we find examples of defective flasks imported from Spain and registered as such in the accounts of the National Mining Bank.[77] Admittedly, once they were sealed in Almadén there was little reason to empty them until they were opened in the refinery for pouring onto the silver flours; and if they were sold to miners, the deal was complete. However, this did not always occur, and in that case their price advantage over boxes of skins was illusory.

In fact, Pizarro's original plan had foreseen many flasks being constantly put back into circulation, although this possibility was not taken into account in the 1807 calculations, and was specifically discounted in Pizarro's letter of 1811. Nevertheless, with the expansion in world quicksilver consumption new flasks were always in demand. And from the position of those transporting quicksilver, flasks had the advantage over skins provided that they were made to a high standard. Ships' captains preferred to carry flasks as ballast since they could be stacked together in the hold, making the construction of wooden 'frameworks' unnecessary, reducing freight charges and allowing ships to weigh anchor more quickly. During the American wars, a ballast of quicksilver, as well as promising the cash necessary to pay troops carried in Crown ships, also offered a new pretext for infiltration by non-Hispanic ships. Foreign ships with a ballast of quicksilver were welcome in American ports; the quicksilver was sold illegally under cover of other merchandise. In circumstances of scarcity, viceroys turned a blind eye, praising the flasks for their greater security; and with the post-war rise in quicksilver prices, the difference in cost between skins and flasks became irrelevant, due to the increase in speculative profits.

(n. 76 cont.)
prices per quintal of quicksilver, and income from the sale of flasks weighing 75 lbs (i.e. quicksilver content only). No separate account for the iron flasks is given.

[77] See ANB, MH PPR, vol. 62, no. 18 (1837), which shows the Potosí merchant Antonio Rojas selling 117 flasks, nine of them defective, and together weighing 93 quintals 33 pounds. Taking this as content weight, the average content comes out at slightly over 74 lbs, which seems plausible. But cf. ANB, MH PPR, vol. 134 (1855), where the accounts for 1854 show 250 flasks sold at 45 pesos each, with a deduction for 12½ lbs missing in one flask.

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VIII

Throughout most of the nineteenth century, the iron flasks constituted a technical innovation that greatly simplified the transport of quicksilver, offered a supply of iron to the American miners, provided ballast for ships cutting transport costs, and practically eliminated loss from leakage.[78] Mediating between practical alchemy and the paradigm shifts brought about by the 'new chemistry', and generating manufacturing and employment in the iron country of Northern Spain, the Pizarros' invention became an indispensable component of the international quicksilver trade which continued long after the loss of the Empire which their ancestor, Hernando Pizarro, had helped to grab for the Crown. So why did what today seems a simple and convenient object, already manufactured in bulk in 1791, become fully adopted only by the time of American Independence some thirty years later?

Several issues were involved: the vested interests of the skins industry; the fallibility of the scientific 'experts' (*facultativos*); tension between the benefits of administered production and private contract; the obstinacy of the inventors, who hoped to administer Crown production; clumsy bureaucracy; arguments over design and manufacture; expense; and, above all, the transformation of Atlantic trade caused by the French invasion of Spain, when contracts were suspended, stocks of flasks left buried in occupied territory, and the invention treated as a trade secret. But it was the French who increasingly controlled the quicksilver trade after the taking of Trocadero. They probably began to set up their commercial network between Almadén, Seville, Trocadero and Bordeaux before the war was over. Yet through all these shifts in the balance of European power, the idea of the flasks persisted; and when, in league with Iñigo Ezpeleta of Bordeaux, the Rothschilds of Paris and London began to take over the Almadén quicksilver trade in the early 1830s, they could count on flasks produced in the Basque country as a precondition for the development of one of their most lucrative businesses.

[78] 'Los Virreyes de Nueva España y del Perú se han declarado . . .': AGI, Indiferente 1783. In the 1890s the introduction of the cyanide refining process left amalgamation on the margins, although the use of quicksilver in small-scale gold-refining continues today in many parts of the world.

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In spite of their use as ballast, however, flasks were not intrinsically cheaper than skins. They promised to realize a dream of efficiency, that 'perfection' sought by the Accountant of Quicksilvers in Mexico, in which imponderables such as leakages could be eliminated and large quantities of quicksilver transported with ease and precision. Neatness, order and predictable flow were imposed on the messy business of moving a messy product. The introduction of the iron flasks anticipates the more recent 'container revolution'. Their convenience as ship's ballast was a decisive argument in their favour, although this also encouraged foreign ships to intervene in Hispanic American markets.

Hence the opinion of the Crown accountant, for whom 'perfection' was more important than price. And, while it may be doubted whether the search for 'perfect accountability' increases the sum of human happiness, there can be little question of its historical significance for the development of twenty-first century capitalism. The modernizing role of accountants in the public and private sectors of different countries deserves examination: instead of necessarily favouring solutions which were immediately *cheaper*, they sometimes preferred more 'perfect' ways of *streamlining and auditing* the increasingly complex tasks demanded of them by the growth of registered trade — which they were thus able, indirectly, to foster. Certainly, this seems to have been the aim of quicksilver accountants in the Bourbon Atlantic world.

Within her own sphere, then, Spain was participating in the industrial, commercial and financial revolution, based on coal, iron and the production and circulation of precious metals, that had gripped the countries of north-western Europe. The central European rediscovery of the art of amalgamation established one precondition for the nineteenth-century development of the quicksilver trade. Another was the late Bourbon invention of the iron flasks. Building on over thirty years of innovation and experimentation, during which modernized containers had rendered the geography of quicksilver-flows more sealed and sleek, the Rothschilds were able after 1835 to acquire quicksilver in Seville and Cadiz, hold and sell it in London and Liverpool, and transport securely to America and elsewhere an essential ingredient for producing one of the bases of their global empire: gold and silver treasure. In return, metallic payments were

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shipped back to London from their agents' money chests on the Pacific coast of America: gold dust and ounces, silver bars, 'hard dollars' and letters of credit — according to availability and the exchange rates of the day. In the end, with the help of the iron flasks the Rothschilds could count on far greater profits from their control of the quicksilver market than had ever been enjoyed by the Spanish Crown.

IX

The rise in quicksilver prices tested mining demand to its limits, although Rafael Dobado has argued that, even in eighteenth-century Mexico, an *abundant supply* of quicksilver was more important than a low price for expanding silver production.[79] From 1835 until 1848, Rothschild's near-monopoly of the quicksilver supply meant he could sell flasks at well over the price he paid the Crown. And his prices had a new and compelling logic: they allowed the Crown to increase the contract price from 37.25 pesos per quintal in 1830, to 54.25 pesos in 1835–8, 60 pesos in 1838–44 and 81.50 pesos in 1844–8. Over the same period, production costs at Almadén fell from 15.95 pesos per quintal in 1830 to 13.90 pesos per quintal in 1848.[80]

Meanwhile, the merchants of Seville and Cadiz were dismayed to see 'their' quicksilver disappearing to London, and 'their' American trade replaced by that of Britain and France. In 1839, Rothschild's agent Anzoateguí tried to soothe the local feeling by putting aside a few hundred flasks for the Spanish to trade with. Rothschild resisted; but an English boat anchored in Cadiz Bay was assaulted with the loss of 38–40 flasks. Anzoateguí wrote to Rothschild that it was politically necessary to sell more

[79] See Dobado, 'Las minas de Almadén', esp. 467.

[80] In 1842, the cost of production in Almadén was 13.40 pesos per quintal; the price charged by the Spanish government to Rothschild was 60 pesos per quintal; the price at which Rothschild sold it in London was about 106.5 pesos per quintal; and the final price paid by miners in Potosí was around 128 pesos per quintal. For changing contracts, prices and costs of production in Spain, see Martín Martín, *Los Rothschild y las minas de Almadén*. For London prices in 1842 as seen from Potosí, see Archivo Histórico de Potosí, Prefectura Departamental 489 (1842), Ministers of the National Mining Bank to the Prefect of Potosí, Potosí, 13 Oct. 1842. According to the Mining Bank, the current price in London had reverted to 4/- per pound of quicksilver (= £20 per quintal of 100 lbs, cf. Table 1), which, at 45d. paid for each Bolivian 'strong peso' of 8 *reales* by the London-based merchant bankers Anthony Gibbs, came out at around 106 pesos 4 *reales* per quintal.

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quicksilver in Andalusia if the contract was to be renewed.[81] Rothschild instructed Anzoateguí to make small sales of 30–40 flasks at the high local price of 92½ pesos per quintal. But Anzoateguí, who had his finger on the political pulse, asked Rothschild for a lower price at which to sell '600, 300, 200 and other numbers of flasks to various interested parties in Cadiz'. In the 1843 contract, Rothschild was required to deposit 1,500 quintals (= two thousand flasks) in Cadiz each year for Spanish merchants to ship to America in Spanish vessels.[82]

Complaints from beneficiaries of the old economic system were also heard in London. In December 1841, the *Circular to Bankers* published a letter sent in August the same year by the president of the Committee of Holders of Spanish Rents, Mr R. Thornton, to the Spanish finance minister, requesting an end to Rothschild's contract. Thornton argued that the monopoly had produced a deficit of 20 million pesos in South American silver production; and he deduced that European exports, especially those of Spain, must have fallen proportionately. The *Circular* also published figures showing a fall in quicksilver exports from London and Liverpool from 14,800 quintals in 1837 to 10,811 in 1839.[83] In the eighteenth century, such arguments would have spoken powerfully to American miners, Andalusian merchants and Crown officials. But now the Crown was staving off bankruptcy, and Rothschild's prices offered relief.[84]

[81] D. P. Anzoateguí to N. M. Rothschild, Seville, 12 Jan. 1839: RAL, XI/38/3–5, Anzoateguí Correspondence. Also D. P. Anzoateguí to N. M. Rothschild, Seville, 23 Feb. 1839: 'Allow me to inform you, to guide you on the state of public opinion, that to refuse to make any sales in this country, which as you know must necessarily consume some quicksilver, would be to offer justification to appeals being made to the Courts, as well as disposing people's minds against the Contract': *ibid*.

[82] D. P. Anzoateguí to N. M. Rothschild, Seville, 2 Mar. 1839: RAL, XI/38/3–5, Anzoateguí Correspondence. For the 1843 contract, see Martín Martín, *Los Rothschild y las minas de Almadén*, 205–23. A total of 1,500 quintals was, of course, trivial in comparison with pre-war Spanish exports.

[83] For contemporary discussion from the early 1840s, which blames the scarcity of money in Britain on Rothschild's quicksilver monopoly, see the *Circular to Bankers*, nos. 712–13, 17 Dec. and 24 Dec. 1841. Mr Thornton's letter to 'Sig. Surra y Rull, Minister of Finance for Spain', dated 7 Aug. 1841, is published in no. 712, p. 187. The *Circular*, which represented the English country bankers, was no friend of the Rothschilds: see Stanley Chapman, *The Rise of Merchant Banking* (1984; London, 2006).

[84] In 1835, Nathan Mayer Rothschild also chose to overlook interest owing on advances to the Spanish Crown, in order to secure the quicksilver contract: see Martín Martín, *Los Rothschild y las minas de Almadén*, 181.

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For their part, Potosí miners followed closely the events in Europe which were transforming the structure and profit margins of their industry. Rothschild's monopoly prices were discussed resignedly. In 1842 Mr Thornton's letter from the *Circular to Bankers* was summarized in Spanish in the Bolivian government newspaper the *Restorer*.[85] Some miners went out of business. Others accepted government efforts at quicksilver price-management and the going price of silver in the Potosí Mining Bank, and introduced home-grown amalgamation technologies that increased silver production while reducing quicksilver consumption and loss.[86] But when world quicksilver prices began to rise again in the 1860s, following a fall in the 1850s with the arrival of Californian quicksilver, diminishing returns led the biggest producers to seek new capital and technologies from outside Bolivia to promote economies of scale. Governments began to liberalize further, bringing silver prices in the Mining Bank closer to those current in the world market. In 1872 the export of uncoined silver was legalized, and the country's finances were restructured on the basis of mineral export taxes.[87]

What were the consequences of economic liberalization for home producers who had participated in Andean regional markets? An example can be taken from Bolivia's Indian peasantry. As tariff barriers against Chilean flour and cereal imports were lifted in Bolivia from the 1860s, the market contracted for the home product, and Potosí Indian cereal-farmers (who had previously exported to La Paz and southern Peru) were left on the margins. Demonetized and marginalized (silver coin in circulation was sucked out to pay for new waves of imports), in the 1890s some peasants reverted to traditional non-monetary exchange relationships between cereal-producing valleys and salt-producing highlands, so as to get rid of agricultural produce that could no longer be exchanged for silver coin. These Andean peasants were

[85] *El Restaurador* (Sucre, Bolivia), 31 July 1842.

[86] For these appropriate technologies, see Tristan Platt, 'Historias unidas, memorias escindidas: las empresas mineras de los hermanos Ortiz y la construcción de las élites nacionales. Salta y Potosí (1800–1880)', in Margarita Menegus (ed.), *Dos décadas de investigación en historia económica comparada en América Latina: homenaje a Carlos Sempat Assadourian* (Mexico City, 1999); also Platt, 'Alchemy of Modernity'.

[87] Antonio Mitre, *Los patriarcas de la plata: estructura socioeconómica de la minería boliviana en el siglo XIX* (Lima, 1981). Eventually, it proved cheapest to export unrefined ore, practically eliminating industrial refining in Bolivia from the end of the nineteenth until the last third of the twentieth century.

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resorting to the 'archaization' of their rural economies in order to compensate for the impoverishing effects of 'free trade'.[88]

But the impact of liberalization on unprotected populations at the frontiers of an expanding capitalist economy is matter for another debate. Here we have simply reviewed the problems and eventual success which accompanied the late eighteenth- and early nineteenth-century invention by Spain of a key technology for launching the new, post-Napoleonic 'global economy'. No less than the central European 'renovation' of the Hispano-Islamic art of amalgamation, iron flasks manufactured in the peninsula facilitated the export of Spanish quicksilver, essential for refining silver and gold. In spite of the loss of most of her Empire, Spain was still able to provide a securely packaged product, now distributed with immense profit through the London market, which remained critical, throughout most of the nineteenth century, for the production of precious metals and the expansion of world trade.

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[88] Tristan Platt, *'The Weak and the Strong', Monetary Policies, Spheres of Exchange and Crises of Trust in 19th Century Potosí (Bolivia)* (Centre for Amerindian, Latin American and Caribbean Studies (CAS), Occasional Publication, no. 31, St Andrews, 2008), 75 n. 114. For the long-distance exchange journeys of Potosí Indians in the nineteenth century, which included the supply of inputs to the silver mines, see also Tristan Platt, 'Ethnic Calendars and Market Interventions among the *Ayllus* of Lipes during the Nineteenth Century', in Brooke Larson, Olivia Harris and Enrique Tandeter (eds.), *Ethnicity, Markets and Migration in the Andes: At the Crossroads of History and Anthropology* (Durham, NC, 1995).

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